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Papers on Hydraulic Engineering. By SAMUEL MCELROY, C. E.

No. 6.—*Fire Service and Hydrants.*

(Continued from page 245.)

Hydrant Improvements.—The following abstract of the patents which have been issued from 1850 to 1864, is given to illustrate the direction which improvements have taken, over the original form described. The hydrants not intended for fire-service have been noted as "drinking" hydrants, as belonging to a different class, but serve to present the same general idea of progress.

Abstract of Hydrant Patents, 1850 to 1864.

DATE.	INVENTOR.	CHARACTERISTICS.
1850.		No issue.
1851.		"
1852.		"
1853. Dec. 13.	Jas. Cochrane.	Drinking hydrant; elastic chamber for ventage of charge.
1854. Aug. 22.	C. M. Alberger.	Hose hydrant, hitching-post, and street washer, with two-way cock.
June 6.	N. W. Speers.	Hydrant cap.
1855.		No issue.
1856. Nov. 11.	Robert Lawson.	Device for ventage.
May 27.	C. K. Landis.	Pump hydrant; application of steam, with float, slide valve, and double valve.
" 6.	C. J. Cowperthwaite.	Drinking; protecting case and nozzle, handle and slide valve.
April 22.	John Culver.	Device for ventage.
" 8.	E. J. Baker.	" "
" 1.	Henry English.	Supply through slotted ports, with square shanked valve.
Jan. 15.	C. J. Cowperthwaite,	Drinking; supplemental valve for disconnection, hand lever, and elastic cap.
1857. Nov. 10.	Lucien Moss.	Gas-pipe and burner within case, to thaw or prevent freezing.
June 23.	G. P. Perrine and J. E. Boyle.	Drinking; hollow piston-rod and nozzle, operated by lever and water head.

Date.	Inventor.	Characteristics.
1857. June 16.	Joel Bryant.	Drinking; supply and discharge ports with double cylinder, operated by rotating handle.
" 9.	W. Bramwell.	Outer case, seat and washer, for disconnection.
" 2.	W. W. Binny.	Drinking; worked by lever and spring valve.
April 21.	A. Hoagland.	Piston operated by crank-arm; ventage by special lifting valved piston.
Feb. 3.	W. Fields & S. Gerhard.	Drinking; pumps by combined plungers and lever.
Jan. 20.	Jas. G. Morgan.	" air chambers and cistern for ventage.
1858. Dec. 21.	S. P. Francisco and W. P. Dickinson,	Piston for ventage, by compressed air.
Oct. 19.	James Swan.	Elastic and metal tube for ventage.
Aug. 31.	James R. Higgs.	Disconnecting valve case, with three valves and one supplemental valve and automatic vent valve and rod.
Mar. 2.	John Parham.	Arrangement of vent, and drops main valve below the supply branch.
" 2.	James Powell.	Drinking; double-chambered cylinder, two plungers, and ports, operated by cam and arm.
Feb. 9.	K. Goddard.	Drinking; upper and lower case; spring valve, operated by plunger and weighted handle.
Jan. 26.	W. Race and S. R. C. Matthews.	Internal case, with annular and supplemental valve for disconnection.
" 5.	Richard De Charms.	Drinking; improved three-way cock, with two air chambers.
" 5.	John Hyde.	Application of syphon tube for ventage.
1859. Nov. 1.	W. James.	Drinking; movable cylinder and fixed piston.
Oct. 18.	J. H. Carter.	" filtering application.
" 4.	C. L. Stacy.	Side valve chest, with cup disks and vent improvement.
" 4.	N. B. Marsh.	Drinking; double plungers, with perforated cylinders.
June 7.	J. Fay.	" ball valve and rod, with supplemental spring valve to prevent waste.
April 19.	W. Race and S. R. C. Matthews.	Drinking; internal supply tube, cap spring and closed seat.
" 5.	J. Bryant.	Annular tube through main valve and stem, with perforated vent top.
Feb. 15.	F. H. Bartholomew.	Supplemental ball valve and joint for disconnecting, with waste chamber and plug.
1860. Sep. 4.	Albert Fuller.	Combined cylinder and case for disconnecting, motion optional for vent valve and rod.
June 12.	Alfred Johnson.	Drinking; diaphragm and spring valve to prevent waste.
Jan. 24.	G. W. Robertson.	" upper and lower chambers, non-conductor packing in upper.
1861. Sep. 10.	D. C. Cregier.	Supplemental disk valve, with valve trunk, for disconnection.
" 10.	G. H. Rogers.	Drinking; guide tube, flanged ring and conical plug, with spring induction valve.
" 3.	L. P. Black.	Pump or hydrant; earthenware plunger and rubber packing.
Aug. 20.	B. F. Moore.	Main valve seat, with thimble, band, and valve on main rod.
" 13.	G. M. Selden.	Independent valves, worked by sliding valve spindle.
May 14.	Joseph Neumann,	Drinking; case and joint above main valve to prevent action of sand, &c.
Feb. 19.	John P. Kenyon.	Plunger and spout tube, for usual valve and seat.
1862. Oct. 14.	Samuel McElroy.	Valve and seat on supply branch, operated externally, with open-hydrant tube.
June 10.	J. Gibson and M. Herberger.	Drinking; elbow, screw-shanked cork, annular gasket, scutcheon and clamp nut.
" 10.	G. J. and H. W. Ross.	Drinking; rotary eduction pipe and spring, connected with plug in supply branch.
May 13.	S. H. Brown.	Inclined planes, slide valve, and double-armed lever.
1863. June 9.	J. Regester.	Combined street and house supply cocks and metal casing.
May 26.	John G. Murdock.	Wasting open-mouth barrel, nozzle, valve, gaskets, and ventages.
Mar. 3.	John McClelland.	Sliding valve with slotted arm and crank motion.
Jan. 20.	Richard Stileman.	Sluice valve and casing to hydrant stem.

It will be observed that a number of patents refer to frost vents and frost prevention, one being for the use of gas jets within the hydrant cases; the remainder refer chiefly to methods of disconnecting

the hydrant tube, without shutting off the water from the service main with which the branch connects, by the use of supplemental valves brought into action for this purpose; one covers the use of a tube free from the internal valve rod and the elevated valve seat.

The vent arrangement cannot be better simplified than in the Philadelphia, or some similar methods of positive motion, or the automatic tube, and the elaborate substitutes are not likely to be generally adopted.

The arrangement for disconnecting may be described, in principle, by reference to Mr. Cregier's hydrant which is simple in character, for its purpose, as adopted to a stand-pipe head.

This head is made with a movable top secured by bolts; its removal permits the detachment of a guide pin to the ordinary valve motion, so that the motion of the rod becomes rotary, and thus operates a screw shaft and supplemental valve fitted on the rod below the line of the hydrant branch; this valve rises to a seat adapted to it, just above the branch, which it thus shuts off from the tube, and the tube being jointed above this seat can be lifted out.

This involves the use of a second valve seat, with a composition valve, valve-shaft, and trunk, and rod extension, as all these parts must be protected from decay.

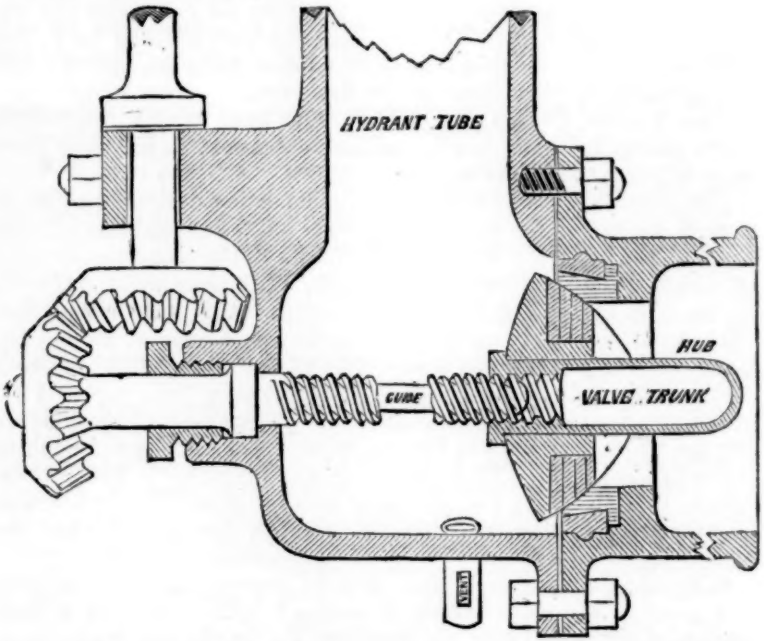
The advantage claimed for these disconnecting devices is an avoidance of the use of the service stop-cocks on the special line of main to which the hydrant is attached, which cuts off the house supply while the removal and replacement takes place. With hydrant bends leaded in, the time of melting, is, of course, much longer than where face joints are made, but in any case the occasions of removal are not frequent, and they can be made at a time of day when house service is nearly suspended. Boston, with 1451 hydrants in 1861, replaced 70; at this rate the term of service is about 20 years average in position, an average which does not warrant any expensive or complicated addition to the hydrant itself. Of 1220 hydrants in Brooklyn in 1863, 39 required removal, giving a much longer average of service. It is doubtful, therefore, whether the range of invention has apprehended the correct line of improvement in these appurtenances.

It is somewhat singular, also, that no importance seems to have been given to the use of tubes of enlarged calibre, or with greater freedom of discharge, with one exception, the precise size of hose-butt, apparently, having controlled this matter.

The arrangement, previously noticed as having been introduced in Brooklyn and in one or two cases in New York, and known as the *Lowry Hydrant*, has superior advantages in the discharge calibre of its tube. This is a "flush hydrant," and used generally at intersections of street mains. A puppet valve and seat is placed on the top of the main, by suitable connexions, the valve being worked by a rod in the usual way; the head of the tube is fitted, when in use, with a screw cover, carrying four or more hose nozzles; according to Brooklyn practice, this cap is removed when a fire is over and stored in

some selected, adjacent place, and a heavy cast iron cover substituted for ordinary street wear.

The effect of this arrangement is to increase the hydrant discharge and to concentrate several hose lines at one point. If the fire is near the hydrant much hose friction is saved; but if distant this friction is increased. Compound nozzles are also open to the objection, in experience, that the hose which is first attached, must be shut off, to admit a second, and so with the third and fourth, and much contention results between the firemen; it is also objectionable to have part of a hydrant apparatus stored away from it, involving delays and difficulties in finding and attaching it; if placed at street intersections, in many cases the intervals must be great between such hydrants and the hose service thereby embarrassed; while their expense has hitherto restricted their adoption.



In view of the foregoing experiences, the *open-throat hydrant*, which is illustrated as to its valve motion on the opposite page, was designed in order to meet and remedy valid objections to existing arrangements.

As will be observed, this device consists of a vertical tube which can be adapted to any form of head, connected by a face joint with a hub which carries the valve seat, and receives the branch main, or can be so formed as to make a T-branch of the street main. This dispenses with the usual bend and its parts, and brings the valve, the seat, and the vent down to the branch main level, and consequently below frost.

The motion is external, by a simple bevel geer, which is cased in, within the hydrant case and is readily accessible.

An improvement is also suggested, in making the hydrant tube with a slight upward flare, so that in case of ice-formation within it, at any point above the valve chamber, the first water pressure from the opened valve, would free the ice-cylinder, so as to permit an active thawing current out of the nozzle. Another improvement is suggested as to the nozzle, which is made with a compound form, so that unscrewing the outer hose-cap will give the usual size nozzle and unscrewing the outer nozzle itself will give a full size opening of four inches and upwards, for the steamer suction pipe.

The advantages secured by this design may be thus summed up :—

1. It is not restricted to location at main pipe intersections, although it may easily be adapted to any calibre of main, and to use as a "flush" hydrant with several nozzles.

2. It secures, without much increase of cost, twice the usual area of hydrant tube free from all working parts and an important increase of head on hose or engine connexions.

3. It provides a hydrant nozzle, of four inches or two and a quarter at will, so that "steamers" may use the larger without loss of power by suction as now required, and is easily adapted to either "flush" or "stand-pipe" head.

4. Its automatic vent is placed below the valve seat and frees the hydrant lower than the hydrant branch.

5. The hydrant tube and valve motion may be removed and replaced without melting or making lead joints, or disturbing any part of the hydrant branch.

6. The workmanship of the valve and seat may be made more perfectly, from easier access.

7. The valve-trunk can be thrown back and the valve chamber enlarged to any desirable extent to secure ample water way, and any desirable amount of power or speed may be given to the valve motion.

8. The valve motion being much deeper, is not choked by ice, in case the hydrant tube is frozen above it, hydrant branches not being liable to freeze, and the tube may therefore be readily thawed when the valve is opened.

9. The valve and valve-seat cannot be obstructed by lodgement of sand or gravel, and the screw shaft is protected from injury.

10. The valve seat hub may be made of any form desired for permanent attachment to the hydrant branch.

In the drawing the valve chamber is represented as a hollow cylinder, but in practice it would be better as a globe.

Summary.—The foregoing discussion of the *office* and *methods of distribution systems*, *progress of fire engines*, *conditions of fire service*, and *defects of distribution*, illustrates, in the facts and principles presented, the need of the most careful and liberal attention to the details of water supply, so as to conserve and realize their legitimate office.

We have it presented as a leading principle, that the cost of water

supply and the annual expenses of administration, are largely exceeded in scale, by the universal and disastrous losses by fire. It is strange that people so practical as we are, so prompt to remedy and prevent evils which occur to property and contingencies which threaten investments, should overlook the importance of the argument on this point, which presents itself in nearly every successive daily paper, and swells into an overwhelming annual aggregate; it is so, nevertheless. Water supply is generally dealt with as a luxury, with which the age of gold, rather than of brass or iron, is more particularly concerned, and the engineer must "make friends with the mammon of unrighteousness" and be able to demonstrate comforting incomes, before his plans can be adopted, or looked upon with favor. Here, in Brooklyn, with a confirmed position in population and wealth, it still required not less than five years of patient and continuous effort to carry the measure, which was twice voted down by the citizens; but the person who would suggest a public election on the question of abandoning the supply, would not be a very popular man now. In all matters of this kind, a few men are always ahead of their age, and are generally unrewarded when they succeed, except, perhaps, in the consciousness of a public sanitary achievement.

We also observe the necessity of keeping the details of supply, as progressive as the appliances of fire service. The introduction of steam fire engines is destined before long, to work a radical change in all the systems of fire protection, as to the paid department of workmen, the methods of application, and the systems of insurance; and our water supplies must be adapted to such changes in method, as a sequence, which ought, in fact, to have been an anticipation.

With regard to the improvement of distribution service mains in calibre and arrangement, which have been discussed and are abundantly justified by the details of experience presented, it need only to be said that this is requisite for all domestic uses, as well as fire service. It is to be hoped, that the day is not far distant, when by common consent, the present practice of niggardly restriction in service outlay, will be abandoned for the true economy of wise expenditure in adequate mains at the outset, and a careful avoidance of annually accruing evils, which "he who runs may read." This is a most important condition of improvement.

In the same scale of correct practice we may certainly include the improvements suggested in hydrants, as to their intervals of position, their details of construction, their sewer drainage, and their use, under a more carefully subdivided system of fire service. A general reconstruction of this kind may seem formidable at first sight, but it does not merit any special apprehension as to cost, or trouble in adoption. It belongs to that order of improvement, which we might term "stratified," since it is but a step or two gained, in a system of progress; which the demands of the age make imperative and the sources of economy, in losses prevented, most amply justify.

The whole discussion of this subject belongs to that class of questions, which it is difficult to exhaust or fully present in their attendant

arguments and we can only indicate, at present, the general course of examination, with the hope that others may assist in its proper conclusion.

Method of Building under Water. By JOHN MOFFAT, C. E.

From the Lond. Civ. Eng. and Arch. Journal, Mar., 1865.
[Read at the Institution of Engineers, in Scotland.]

Quay walls are the principal objects of subaqueous construction; and these have hitherto been made of wooden or iron framing, or of stone or brick masonry. In the former case they depend for their stability chiefly on the strength given by cohesion, and in the latter on that afforded by their weight. The security and durability of masonry, as compared with any description of framing, in every kind of harbor construction, are so great, that it would be invariably adopted, were it not for the consideration of time and expense. A pier can always be made of wood or iron much quicker and cheaper than of stone; and on this account they are frequently resorted to in cases where the time or the money at the disposal of the engineer render the superior structure unattainable.

About ten years ago I had an extension of the outer quay and breakwater at Ardrossan Harbor to execute, which had to be completed in one summer, and for a limited sum. All the works at that harbor have hitherto been executed in stone, except a small pier of timber, which, though cheap at first, turned out in the long run to be the dearest work we had, on account of its being destroyed by the *Teredo navalis* in about ten years. We had also found that cast iron is corroded so rapidly, as to render an iron structure nearly as objectionable as a wooden one. And I was thus induced to turn my attention, to devising a plan for executing the building in masonry, within the limits assigned to me. And I succeeded in doing so, by the plan which I shall now proceed to describe.

In a stone pier, the portion which consumes most time and money, is that under low water. Hitherto this portion has been built in separate masses in wooden caissons, and floated to its position when completed, the sides of the caisson being disengaged when the mass of masonry had been set. Or it has been formed entirely of large squared ashlar, dropped into its place by means of water lewis, or set by means of the diving bell. At Ardrossan the masonry under water has been built entirely of ashlar, set partly in the first way, and partly in the second. Where set by the water lewis, the stones are laid so that the beds are not horizontal, but at an angle of 45°. After the first row of stones has been laid, and which must be done with very great care, the remainder are lowered so as to catch the upper edge of the inclined bed, and are slipped along it until they reach their position, when the lewis is disengaged in the usual way. Where set by the diving bell, the courses are horizontal, and form a solid mass of ashlar of the ordinary construction.

I found by calculation that with the plant at my command, I could

not complete the extension, by either of these methods, in less than two seasons, and that the cost would exceed the sum at my disposal. It then occurred to me, that I could attain my end by forming the masonry under low water of large hollow masses of brickwork, constructed in the graving dock, and floated to their position in the quay, after reaching which they could be filled with concrete. And on trial I found that this plan could be easily carried out, and furnished a method of submarine masonry much cheaper and quicker than any I had yet tried.

The average depth at low water was nearly 20 feet; and I leveled out the foundation, and laid three courses of ashlar with the diving bell in the usual way, so that the upper bed was about 15 feet from low water. The hollow brick masses were made 15 feet long, 15 feet deep, and 11 feet thick. The bottoms were of cast iron plates ¾-inch thick, strengthened with projecting feathers along the edges. The walls were 20 inches thick, formed of large bricks 20 inches long, 10 inches broad, and 5 inches thick, set in Roman cement, and strengthened by horizontal strips of hoop-iron laid along the courses. When finished they were nearly water-tight, and their specific gravity was a little less than sea water. They were floated to their positions by being attached to one of the harbor punts, set at low water, and then filled with concrete. The ends were formed with alternate salient and re-entering angles, so as to lock into each other. The wall above low water was built of ashlar and rubble in the usual way; and the work was finished in a satisfactory and substantial manner in the summer of 1855. The length of the pier was fully 300 feet, the average breadth 70 feet, and the cost was under £10,000. The average cost of the brick masonry under low water was 7*d.* per cubic foot, or about one-half the cost of solid ashlar.

The work has now stood for nine years exposed to a rough sea and a heavy traffic, and is as perfect as when completed. Four years ago I had occasion to cut down the masonry to low water, in order to erect a 20-ton steam crane, which I constructed on the top of one of the brick masses as a foundation; and I found it then to be in the same condition as when set.

I had recently occasion to extend another of the quay walls, in water about 10 feet deep at low water; and this extension I resolved to construct in a similar way to the previous one, but in a cheaper manner. The bottoms were made of wood instead of iron, and the bricks were of two sizes, at the ordinary price, instead of the large size previously used, which cost nearly twice as much. I originally made the brick masses only 15 feet long, from a fear that larger sizes would be unmanageable. But having found them to be very easily handled, I resolved to make them on this occasion double the length, or about 30 feet long.

This extension was also successfully constructed in a very short time; and the drawings on the wall are intended to show the construction in detail. From the ground plan it will be seen that the extension is about 110 feet long, 35 feet broad, and the walls 27 feet deep.

The bottoms of the brick masses, which varied in length from 29 to 33 feet, were formed of a light wooden framing, formed of two beams of yellow pine 9 inches square, to which was spiked a platform of 3-inch white pine battens. These were caulked so as to be water-tight, and set on four logs on the bottom of the graving dock, as a foundation on which the brick caissons were to be built. The outer walls were formed of common bricks of two sizes—the one 9½ inches long, 4¾ inches broad, and 3½ inches thick; and the other 13 inches long, 6½ inches broad, and 3½ inches thick. These were laid in alternate courses—the small bricks in one course, and the large ones in another, header and stretcher alternately, so as to give proper bond. The outer walls were thus 20 inches thick all round, and the front and back walls were connected by three cross walls one brick thick. The whole was set in Roman cement, and strengthened with hoop-iron laid along the bed of the courses. The weight was adjusted, so that when finished they floated, with the top about one foot above the surface of the water.

The size was determined by the length of the logs from which the longitudinal timbers of the bottoms were cut. For these I selected logs varying from 29 to 33 feet long, and nearly 18 inches square, which were cut into four timbers, the full length of the log, so as to avoid any waste. The average size of the caissons was 32 feet long, 13 feet deep, and 10 feet thick. When the brickwork was finished, a small beam of timber was laid along the top, and connected with the bottom by means of two long bolts of wrought iron 2 inches in diameter. The water was then let into the graving dock, the brick masses or caissons were floated, and attached to the diving bell barge, or to a crane punt, and towed to the place where they were to be set. They could be raised about 4 inches above the line of flotation by means of the crane on the punt, and were suspended at this level above the bottom, by means of the long bolts above described, until they were brought to their exact position in the work, when they were at once lowered on to the bottom, and filled with concrete. When they were set in their places, the top beam and bolts by which they were suspended were removed and used again. The concrete used to fill them was formed with a mixture of good hydraulic mortar and cement, and large gravel, in the proportion of 1 of the mortar to 2 of gravel, which I found to set in a short time into a very hard compact mass. All the brick caissons were of an oblong form, with square ends, except the closing one across the end of the quay, which was formed with rounded corners to a radius of 13 feet. I found that forming the ends with salient and re-entering angles caused a great deal of trouble both in building and setting, and was of very little use.

These operations were all carried on without the slightest difficulty. As a proof of which, I may mention that on one occasion I built four of the caissons in the graving dock at once, and floated them into their places in two tides, thus completing 126 feet of wall in twenty-four hours. When the brickwork was finished the masonry was begun on the top, and completed with a facing of ashlar and a backing of rub-

ble in the usual way; and the space between the walls was filled in with stones.

The cost of the work was £1881, or £51 per running yard, being less than the cost of open timber piling, which would have been greatly inferior both in efficiency and durability. The cost of the portion under low water was 4*d.* per cubic foot, concrete included.

I may mention that I am at present constructing another wall in a similar way, and that I have made some of the brick caissons even larger than I have stated. But from what I have seen, I think that about 40 feet long is the largest size which admits of their being easily handled.

Of course the possession of a graving dock offers great facilities for the construction of these floating masses of brickwork. But there is nothing to prevent them from being built on the beach in sheltered places by tide-work, and floated off at high water when finished; or they may be constructed on the ground above the level of high water, and launched on slip-ways like a ship.

Steel Bridges.

From the London Mechanics' Magazine, February, 1865.

At the meeting of the Literary and Philosophical Society on the 24th ult., Mr. S. B. Worthington, C. E., stated that he had lately constructed a swing bridge for carrying a railway over the Sankey canal, in which the girders are made of Bessemer steel plate. The object of using steel instead of wrought iron, was to reduce the weight of the girders. The girders are four in number, about 56 feet long, with bearings varying from 30 to 40 feet, and two feet deep. They were manufactured by Messrs. Benjamin Hick and Sons, of Bolton, from steel tubes made by the Bolton Steel and Iron Company; and were tested with loads of a ton to the foot, or more than double the weight which they could possibly be called upon to bear. The deflection varied from ½ inch to 1 inch according to the length of the girder, and there was no permanent set on removal of the testing load.

The plates used varied from ¼-inch to $\frac{7}{16}$ in thickness; and the average tensile strength of a considerable number of plates tested, was upwards of 36 tons to a square inch. The weight of the girders was about ⅝ of the weight which they would have been if wrought iron had been used. The contract for this bridge was made in November, 1863, and the bridge was erected during the past summer.

Bursting of a Reservoir.

From the London Mechanics' Magazine, Dec., 1864.

On the 31st ult., a catastrophe occurred at the seaport town of Harrington, Cumberland, similar in some respects to that which spread such devastation around Sheffield in the early part of this year, though upon a much smaller scale, and fortunately unattended with any loss of life. About 11 o'clock on that day a reservoir, three acres in ex-

tent, situated at a short distance from Harrington, burst, and deluged the main street with a wide stream described as some 4 feet or 5 feet in depth, which rushed down the street with a loud roar, the main body of water finally emptying itself into the harbor. The reservoir was one recently constructed to supply the new iron works of Messrs. Bain, Blair, and Patterson. It was constructed in a valley, the adjacent hills forming two sides, and the low end being shut in by an embankment about 300 feet in length and 20 feet high. This bank was 5 feet thick at the top, and it gradually spread out towards the base, sloping on either side. The sides were formed of battered earth and clay, a section of clay puddle being placed in the middle. It is about ten months since the construction of this reservoir was commenced, and it was almost completed when this catastrophe occurred on Wednesday. The recent heavy rains had filled it, and the by-fall which carries the overflow into a beck, and so into the harbor, proved inadequate to carry off the surplus water, which flowed over the side of the embankment, and, it is conjectured, washed away the earth on the outer side, and so gradually diminished the thickness of the embankment at one place, until it was incapable of resisting the pressure from within, and finally the water burst through, making a chasm some 10 feet wide.

Engineering Archæology.—The Historical Locomotives at Kensington.

From the London Builder, No. 1148.

People talk very glibly about invention and its progress, but we have often had occasion to notice that but few have any clear notion of what industrial invention really is, while a philosophic history of invention has yet to be written. Invention has been termed the poetry of science, and one popular belief about inventions would maintain that they are struck off like the stanzas of a poetical *improvisatore*. But very few inventions, however, could be traced to such a source, and the history of the arts shows that time, accident, and tentative experiment are, after all, the greatest inventors. One of the chief features observable in the maturity of any invention is its gradual and slow evolution, by the work of many brains, of many hands, of many circumstances of time, place, and chance. So slow and gradual is this progress, that the different stages in its history are as difficult to note as would be the progress of the hands of a clock unprovided with a dial-plate; and the different stages are difficult to determine, not merely with regard to entire machines or processes, but also with respect to the different details and minor operations making up these engines or these processes. As a natural result, when inventors or their descendants do at last come to understand the importance and value of what they have been doing, there take place endless controversies as to priority of invention. Witness that of the blast-pipe, for which there are several claimants. The importance, for reasons of social and commercial polity, of determining the laws of the development and progress of industrial improvement is scarcely recognized,—although the patent law

and other laws bearing on inventions may be supposed to have some such theoretical basis. A generalization of this kind could only be conducted on a firm groundwork of historical truth, and there are many difficulties in the path of an investigation in this direction. To mention only one. There is scarcely one important modern invention which is not claimed for a distinct and different inventor in each of the more important civilized countries of Europe. The first originators of many of the different important steps in the elaboration of the steam engine are thus subjects of fierce contestation between the *savants* of England, France, and Germany. It would be scarcely possible to get at any true account of a question of this kind without studying the records and claims in these three languages at least. It is the French who show the greatest ardor and vivacity in these discussions; and, we regret to say, these patriotic sentiments have not in all cases been tempered with many scruples as to the means of maintaining, or rather of annexing, honor of this kind. We say this advisedly, having in our memory some yet unpublished discoveries as to the history of the steam engine.

We thus look upon the Museum of Patents at Kensington, mainly founded by Mr. B. Woodcroft, and greatly extended by the zeal of the present Curator, Mr. F. P. Smith, as being of yet greater importance than is generally acknowledged. This Museum, even in its comparatively undeveloped state, is not merely an historical record of inventive progress,—is not merely a museum of engineering archæology,—but it is also a place whence may be drawn some most valuable lessons towards a philosophic theory of the development of invention. One lesson, apparent to the most casual observer, is that an invention is not a thing of spontaneous, inspired production, but is rather a plant of slow growth,—sown, nourished, tended, and reaped by many different hands. This view is a rather disenchanting one to take, however true it may be. The popular imagination seems to always require a corporeal object for the embodiment of its fancies. It delights in a hero, its sight does not range so far over the intellectual horizon as to perceive a principle,—it can only see a person. It is forgotten that men's powers—the term being used in the widest sense—differ but little in extent from the physical stature of a given number of persons. The popular belief thus, for instance, invests Watt with the invention of the steam engine; Arkwright with that of spinning machinery; Fulton with marine propulsion by steam; George Stevenson with the first invention of the steam locomotive. A brief account of the locomotives already existing in the Kensington Museum of Patents would dispel this last belief, and even without greatly shortening Geo. Stevenson's status. At the time we write, too, the celebrated "Sanspareil," the river engine to Stevenson's "Rocket," built by Stevenson's rival, Timothy Hackworth, is just now being re-erected in the Museum, in company with its former competitor of the famous contest on the Manchester and Liverpool Railway, in 1829.

In the matter of priority of invention in, or rather of attempts at, land propulsion by steam, the French may well claim to be our *devan-*

ciers, and we do not think that any true Englishman will be inclined to grudge them this honor. The first steam carriage seems to have been made by a Frenchman, Cugnot, in 1769,—that same marvellous year which witnessed the birth of Napoleon I., Wellington, Humboldt, Mehemet Ali, Lord Castelreagh, Sir M. I. Brunel, Cuvier, and the first patent of Arkwright, the first patent of Watt, as also some other events almost as great in their eventual influence on the present era. An engine made by Cugnot is still in existence in the Conservatorie des Arts et Métiers at Paris. It has a copper boiler, very much like a common kettle without the handle and spout, furnishing with steam a pair of 13-inch single-acting cylinders. The engine propels a single driving-wheel, which is roughened on its periphery. Altogether, this engine bears considerable testimony to the mechanical genius of its inventor. It was unsuccessful, having got overturned once or twice on the very bad roads then existing in France, and it was put on one side. It is stated, however, that arrangements were made in 1801, to put it to work in the presence of Napoleon Bonaparte. The departure, however, of Napoleon for Egypt, prevented the trial,—a circumstance which recalls Fulton's subsequent unsuccessful negotiations with Napoleon for aid in attempting marine propulsion by steam. Watt then, in 1784, patented a locomotive engine, the boiler of which was to be "of *wood*," hooped like a beer barrel. Watt, however, had not much faith in steam carriages, and he objected to the attempts made in this direction in 1784 by William Murdoch, his very able assistant. The miniature engine made by Murdoch in that year is still carefully preserved at Soho. Careful and elaborate researches, such ast hose lately made by Mr. Zerah Colburn* into the history of the locomotive, seem to more and more confirm existing impressions as to the great part done by Trevethick in the introduction of the locomotive engine. In 1802, he and his moneyed partner Vivian patented the application of the high-pressure engine to steam carriages, and one of these was made, put to work in Cornwall, and exhibited in London. A model locomotive made by Trevethick in 1802, is now in the Museum of Patents, at South Kensington, having been found out in Cornwall by the present curator Mr. Francis P. Smith. The boiler is fitted with an internal double flue, and a chimney of small diameter. Mr. Colburn has shown clearly enough, and in spite of previous mis-statements, that Trevethick understood the value of the blast formed by the exhaust steam when turned into the chimney, and the practical sufficiency of the adhesion between smooth metallic surfaces for propelling the locomotive and its load. Trevethick's engine of 1804 was able to work over a rough tram-road at the rate of 5 miles an hour; but in Cornwall, where fuel was then so dear, the comparatively high quantity of coal consumed rendered this performance of inferior commercial value. The Northern districts of Newcastle-on-Tyne clearly offered the fairest opening for the childhood of the locomotive, and accordingly Mr. Blackett, the proprietor of Wylam Colliery, wrote in 1809 to Treve-

* "Locomotive Engineering." Glasgow: W. Collins, 1864.

thick respecting his locomotive. It appears that, at the time, Trevethick replied that he was too much engaged; but in 1811, however, he sent an engine to Newcastle. It was not put on the Wylam railway, but set to drive a foundry.

At this time a locomotive was being made by Murray, of Leeds, at the order of Mr. Blenkinsop, of Middleton Colliery, near that town. It will be remembered that Mr. Blenkinsop's name is connected with the employment of a strong rack-rail on the line, into which worked a toothed pinion driven by the engine. A horizontally-placed cylindrical boiler was used, in which were placed two vertical steam cylinders. The boiler had a single internal flue, containing the grate at one end,—like a Cornish boiler—while the chimney rose out of the other end of the flue. A pair of cranks on each side of the engine drove a toothed wheel, and these two wheels themselves propelled a larger toothed wheel, on the axis of which was a pinion with coarse teeth working in the rack-rail. With such a light engine as one of 5 tons, and working at the slow rate of only 3 miles an hour, Mr. Colburn considers that we should be obliged to use a rack, and that thus Mr. Blenkinsop did not deserve the ignorant ridicule which has been directed against his rack and pinion. In fact, Murray's engines on Blackett's plan were the first locomotives ever worked permanently and on a commercial scale, and this line between Middleton and Leeds is in reality the first commercial railway. It is not, perhaps, generally known in England, but it is stated by Mr. Colburn, that "as late as 1848 the rack-rail was adopted upon an incline of 1 in 17, on the Madison and Indianapolis Railway," in the United States. "This incline, which has since been superseded by a line with practicable gradients, rose from the north bank of the river Ohio at Madison, and was about five-eighths of a mile in length." The engines provided had five steam cylinders in all, actuating, in a way not to be made clear without a sketch, a cogged wheel working on a rack-rail.

The next step was the commercial working out of the adhesion of the driving-wheels. This was done by William Hedley, the colliery viewer of Mr. Blackett, of Wylam; but it is probable that this would have been done by any one who first built a rather heavier engine than that of Murray's. Hedley thus, in 1813, constructed the engine now in the South Kensington Museum, but which has been at work near Newcastle, down to such a recent date as 1863. It has been known there many years under the name of the "Puffing Billy," a nickname given to its maker, Mr. William Hedley, by the colliery hands, from the fact of his being rather stout, with a consequent shortness of breath. Mr. Hedley first of all made an engine somewhat like that of Trevethick's, with a cast iron boiler, provided with a single internal flue, and working by adhesion on a smooth rail. This engine was not very successful, from a deficiency of boiler power, and from the fact of its having only one cylinder; but it clearly proved the possibility of doing away with the expensive and cumbrous rack. The "Puffing Billy" was then made. The inscription on it states that it was built in 1813, by Jonathan Foster, engineer, of Wylam Colliery, under the

superintendence of Mr. Blackett, owner, and of Mr. Hedley, viewer of the colliery, in order "to haul coal-laden wagons along a railroad to Lemmington, where the coals were shipped in keels." This railroad was a substitute for the old tramroad, and was laid down on the site of the latter, between the years 1807 and 1811. The "Puffing Billy" has a wrought iron boiler, containing a return flue, the chimney being at the same level as the fire door. There are two vertical cylinders, driving beams centered each at one end, termed the "grasshopper" beam—a plan first due to Oliver Evans. The motion of the wheels is given to the four wheels by toothed gearing. An original document of great interest and instructiveness, is framed and glazed and hung to this engine. It appears that the noise and smoke made by this engine were considered a nuisance by some of the people living in the districts it traversed. They accordingly threatened to indite the "Puffing Billy" as a nuisance, and their complaints were so strongly urged, that Mr. Blackett found himself obliged to take counsel's opinion on the matter. The barrister, no doubt a noted one in his day, evidently agreed with the neighbors in their bad opinion of Mr. Blackett's engine. The case being put to him, he writes on the back of the document, that, "It does not appear to me that there is any objection arising from the lease itself, to Mr. Blackett's conveying his coal wagons by means of this steam engine; but I think that the use of such an engine may be deemed a nuisance to A. if the smoke and noise so occasioned thereby render his habitation unhealthy or uncomfortable; but this must entirely depend upon the quantity of smoke and noise occasioned, and the distance of the house of A. from the wagon-way," —(signed) R. Hopper Williamson, Newcastle, 12th September, 1814. But the most amusing bit is a note, apparently the result of an afterthought of the learned lawyer: "If the noise of this engine disturbs the cattle grazing on the land adjacent to the wagon-way, so as to injure them with regard to their feeding, I think it may be considered a nuisance." In all probability Mr. Williamson's capacity was rather above than below the average; but this is one of many more instances that shows the difficulties to be encountered in the introduction of any new thing. It is not very likely that such an opinion would now be given, or that we shall ever abolish locomotives for fear of disturbing the digestion of grazing cattle; but the first thing has been done, and the introduction of traction engines is just now greatly impeded by the same difficulties which beset the Puffing Billies of 1813. At the same time, it is clear that horses are more liable to be frightened by an engine on common roads than on a line,—or, rather, more properly speaking, the engine is brought within sight of a greater number of horses when it is made to travel on a common road. But it is well known that horses very soon get accustomed to a railway locomotive, and there is no doubt that they would just as soon forget their fear with the traction engine.

About a couple of years after the construction of the "Puffing Billy," Mr. Hedley built a yet more efficient engine for the Wylam Railway. In the same way as he had first put to commercial use the ad-

hesion of smooth surfaces for railway traction, so did he first apply the return flue boiler and the narrow chimney. By the way, talking of "adhesion," we think that this term is often used very improperly. Adhesion only takes place between two surfaces of the same substance of the same—or of nearly the same—molecular structure, and consequently similar surface. Adhesion thus does not take place between a cast iron surface and a wrought iron surface,—between (say) a cast iron wheel and a wrought iron rail. The grip is in this case produced by simple friction without any adhesion, properly so called.

A careful observer of the doings on the Wylam Railway was Geo. Stevenson, and he persuaded his employers at the Killingworth Colliery to construct an engine which was finished towards the middle of 1814. Its boiler, 8 feet long and 34 inches in diameter, was carried on four 3-feet wheels, and provided with a single internal flue. Two vertical cylinders were placed for half their length in the boiler. The motion for driving the wheels was almost the same as that in the "Puffing Billy." It is stated by Mr. Smiles that the speed of this first engine of Stephenson's was only three miles an hour; a year's trial with it showed that it had no advantage in point of economy over horse power,—being thus much inferior to Hedley's engines. This weakness of Stephenson's first engine was due to the low boiler power produced by the use of a single flue and a chimney of large diameter with its weak blast, unaided by exhausting the waste steam into the chimney. In 1815, Stephenson made his second engine according to the patent which he took out in that year. A different kind of gearing was adopted for driving the engine, and additional adhesion was obtained by coupling the wheels of the tender to the engine by means of an endless chain. Stephenson also used springs, according to a suggestion of Mr. Nicholas Wood. George Stephenson also applied a strange and even absurd scheme to some of the Killingworth engines as a substitute for springs. This consisted in adapting a number of pistons sliding in cylinders fixed to the bottom of the boiler, and in communication therewith. Stephenson, in his own words, supposed that as they "acted upon an elastic fluid, they produced the desired effect with much more accuracy than could be obtained by employing the finest springs of steel to suspend the engine." Of course the plan had to be at last abandoned, after some unsuccessful trials. At this time, and some years previously, the placing of steam-carriages on common roads was being attempted,—a feat which is now being carried out in our own time mainly for agricultural purposes. The wedding of the wheel and the rail put an end for the time to the experiments in this direction, conducted by Griffiths, Gurney, and others. Mr. Colburn remarks on these experiments, that while road locomotives had ample adhesion, they only lacked evaporative power. "The steam blast, which for railway engines running at a slow speed, and having insufficient adhesion, was as yet hardly required, nor, for some of these engines, even admissible, was therefore of great importance to the road locomotive engineers. Goldsworthy Gurney, then a surgeon and lecturer at the Surrey Institution, has claimed the discovery

of the steam-jet in 1820,—the year, by the way, in which Nicholson's patent for various applications of the steam-jet expired. In 1820 and 1821, Gurney employed the jet for promoting combustion in laboratory furnaces, for decomposing various compound bodies, and for working platinum; in 1824 he applied jets of steam, taken directly from the boiler, to increase the draught in the chimneys of the steamboats *Alligator*, *Duchess of Clarence*, &c.; in 1826 he applied steam in the same manner to increase the draught in the chimney of his road-locomotive; and in an *ex parte* statement not long ago published by Mr. Gurney, he alleges that he "supplied Timothy Hackworth with the blast-pipe employed by that engineer in the locomotive 'Sanspareil,' which so nearly won the Liverpool and Manchester prize in 1829." It would seem, however, that Hackworth used the single contracted blast orifice about two years previously to 1829.

Timothy Hackworth was a practical engineer of much ability, and, though not so successful as George Stephenson, it is probable that his mechanical powers were little, if at all, inferior. He helped to make the "Puffing Billy" at the Wylam Railway; in 1824 he was the manager of George Stephenson's locomotive foundry at Newcastle; becoming, in the following year, the locomotive superintendent of the Stockton and Darlington Railway. The engines of this line opened in 1825, were made by Stephenson, and they gave such bad results that it was stated that the directors, as late as 1827, were thinking of altogether giving up locomotives. Hackworth, however, took in hand one of the engines on the line, made by Wilson, of Newcastle. Hackworth applied the return-flue to the boiler, and, above all, he applied to it the blast-pipe. The "Royal George" was thus the best locomotive of its time, as it was, besides, fitted with the then novelties of "a cistern into which a portion of the exhausted steam could be turned to heat the feed-water; it had short-stroke force-pumps, worked by eccentrics; adjustable springs, instead of weights, upon the safety valves; and a single lever reversing-gear."

Two years after the application of these improvements to the "Royal George," in 1829, took place the Rainhill trials on the Manchester and Liverpool Railway, which had the effect of bringing to a head most of the existing knowledge in locomotive traction. One of its most important results was the first application of the multitubular boiler to the locomotive. The invention of this important form of boiler has afforded, and still affords, a field for both intestine and international wars as to its priority of invention. The English claim the multitubular boiler; so do the French; and so do, we believe, the Americans. Perhaps a Chinese claim may be yet put forward. In the mean time, Mr. Colburn shows that it was first prepared by a London engineer, Mr. James Neville, of Shad-Thames, in specification No. 5344, A.D. 1826. This is an important document in engineering archæology, as it annihilates the pretensions of the French claimant, M. Marc Séguin, who only patented the multitubular boiler in France in 1828.

Thus were combined and brought into practice all the essential points

of the present locomotive, which has only been since improved by, in the main, the mere effect of time,—of time and experiment, eliminating inferior forms of detail. Nevertheless, the then existing locomotives were by no means very successful machines; such distinguished engineers as Messrs. Walker and Rastrick reported against their use on the Liverpool and Manchester Railway; and they were confirmed in their impressions by a man of such ability as Mr. Nicholas Wood, who (just as Smeaton firmly believed that steam-engines could never do better work than pumping up water for water-wheels) gave it as his conviction that no locomotive could be made to go faster than 8 miles an hour. Thus, even so late as the spring of 1829, the directors of the Liverpool and Manchester Railway were thinking of applying fixed engines and ropes for working the line. Fortunately, however, the counsels of two or three members of the board prevailed, and it was decided to make a last trial of locomotives. As one of George Stephenson's engines had already failed on the line, a prize of 500*l.* was publicly offered to all comers on the 25th of April, 1829.

The conditions that engines had to fulfil have been often published. One of these was, that the engines should burn their own smoke; and it is a pity that this "condition" has not even now been fulfilled, as every railway passenger knows to his cost. The only engine ready at the appointed time was the "Rocket," entered by Robert Stephenson; Hackworth's "Sanspareil," Braithwaite and Ericsson's "Novelty," and Mr. Brandreth's "Cyclops" were not ready at the appointed time. The "Rocket" and the "Sanspareil" (both somewhat altered) are now in the Kensington Museum, the last, as we have stated, being just now there re-erected. Both are four-wheeled engines. The boiler of the "Rocket" is traversed by a number of copper tubes, and its two inclined cylinders work crank-pins on the driving-wheels at the front or smoke-box end of the engine. The honor of the application of the tubular boiler is not due to the Stephensons, but to Mr. Booth, the secretary of the Liverpool and Manchester Railway. The diameter of the driving wheels was 4 feet 8½ inches, and that of the traveling-wheels, 2 feet 6 inches.

With regard to the "Sanspareil," it is stated that this was the second engine to which was applied the blast-pipe, the "Royal George" (1827) being said to be the first.* The exhaust steam from each engine is taken into the chimney through a blast-pipe. It also appears to have been one of the first engines with coupled wheels, of which it had four. The most striking peculiarity to the eye accustomed to the present locomotive is, that the driver stood beside the chimney, the boiler being completely traversed by a return flue. The boiler is cylindrical, about 4 feet in diameter and some 6 feet long. The fact that the apparent front end is in reality the hind portion which was coupled to the tender, has misled some of the writers of treatises on the steam-engine, causing them to figure the tender in front. An inspection of the engine would appear to show that the driver stood on the

* See the London *Quarterly Review* for 1858, and the *Practical Mechanic's Journal* for 1850 and 1851.

tender in order to fire the boiler. The cylinders are vertical, and, in the original engine, were 7 inches in diameter, the stroke being 18 inches. The two front wheels are fitted with crank-pins, driven by the connecting-rod of each engine. The "Sanspareil" was tried on the 13th of October, 1829. The total weight of the engine and load being 19 tons 2 cwt. The failure of the feed-pump, however, led to its stoppage, as the boiler could not be kept filled with the necessary water. It was also unfortunate with regard to one of the steam cylinders cracking through the bore into the steam vent. The rate of evaporation, and consequent tractive power of the "Sanspareil," was, however, higher than those of the "Rocket," the successful engine. It is stated by Mr. Hick, of Bolton, the donor of the engine to the Kensington Museum of Patents, that it was purchased by the Liverpool and Manchester Railway, after the trials. In 1831 it was sold to Mr. T. Hargreaves, of Bolton, in order to work on the Bolton and Leigh Railway. In 1837 the old cylinders were replaced by new ones of larger dimensions, and the original wheels with wooden spokes were replaced by cast iron wheels, with hollow spokes. It continued till 1844 on the Bolton and Leigh Railway, but was, by that time, found too small and weak. Mr. Hargreaves then removed it to his colliery at Cophall, near Chorley-lane, and fixed it over a coal-pit, in order to drive a pumping and winding apparatus, a pair of wheels being removed for a set of toothed gear. The boiler was not used, the engine being driven from a stationary boiler. It thus worked up to the end of 1863, when it was removed solely in consequence of the coal-pit being exhausted. Mr. Hick, of Bolton, happened to pay a visit last year to the Kensington Museum, and, having seen the other engines there of historic fame, he determined to add the "Sanspareil" to the number. Mr. Hargreaves then presented the engine to Mr. Hick, who, in his turn, gave it to the Museum, where, in the words of Mr. Hick's letter, the engine, after all its chequered and eventful career, may end its destiny "in peace and not in pieces." It may not be uninteresting to state, that the railway companies on the road from Bolton to Liverpool carried the old engine free of cost, according to the suggestion of Mr. F. P. Smith, that the venerable engine which had carried so many, should, in its turn, have its own carriage franked to its last resting-place.

The "Novelty," though very unsuccessful—as it was very soon disabled by an accident—displayed high constructive power, and is considered by some good judges as being in many respects the best designed engine of the four. It was a four-wheel tank engine; its boiler consisted of an upright cylinder for the fire-box, and a horizontal barrel 15 inches in diameter, and about 12 feet long. The flame was taken from the fire-box through the barrel by means of a tube folded backwards and forwards on its way to the chimney. The two steam-cylinders were placed vertically in the framing, being 6 inches in diameter, with a 12-inch stroke. The diameter of the wheels was 4 feet 2 inches. Mr. Burstall's "Perseverance" very soon gave up, and was found unfit for the trials.

It would be a natural remark to make, that the greater number of the engines and machines which have been so long at work have been greatly altered from the original construction by the exigencies and accidents of practical wear and its attendant repairs. Like John's old knife, which still remained "John's old knife," though it had received about half-a-dozen new blades in succession, and about as many new handles, it might be doubted whether these engines really represent their original construction. In one sense this may be true, and it is probable that only a portion of the original raw metal is still in combination. But then it must be remembered that in piecemeal repairs any part repair is in a great measure tied to the original form. The new blade of the old knife has to conform to the existing handle, and the new handle has to be made to the shape of the blade. The same must be, more or less, the case with repairs to an engine or machine. At the same time, such a consideration points to the absolute necessity for a correct history—or rather engine biography—being appended to each engine, pointing out where and what alterations and repairs have been made.

The Patent Museum at South Kensington, only yet needs the "Novelty" to complete the trio of the engines which figured at the great Rainhill contest. It is not now known where the "Novelty" at present is, or indeed, whether it is even still in existence. We believe that Mr. F. P. Smith is anxiously looking about for it, and we hope that he may be successful in his search. What lessons of the way in which "Fortune turns her wheel," may be read by a look at these old engines,—the progenitors of the apparatus,—the use of which is stamping its impress on present life in so many direct and indirect ways. The two Stephensons are now dead, but their engine, which killed Mr. Huskisson, raised their fortunes above those of perhaps any other engineers of their time. Timothy Hackworth is now dead, but his works at Newcastle, like those of the Stephensons, are still flourishing. The Messrs. Braithwaite are now living, but their factory has been given up, and their partner of 1829, the Swedish engineer, Ericsson, is now building "Novelties," in the way of gunboats for the Federals. In centuries hence, time will have thrown its halo of distance round these engineers, and their doings will be scanned with a kind of romantic interest. Let us hope that, in the course of the next century, the Government will have provided a decent building for the objects which represent such important interests, but which are now sheltered in the crowded and dark shed at South Kensington.

For the Journal of the Franklin Institute.

General Problem of Trussed Girders. By De Volson Wood, Prof. C.E., University of Michigan.

Continued from page 107.

20°. It is found by subjecting equation (65) to experiment, that R is not constant for beams of different forms, when made of the same material. It is also found that the value of R which is found from

rectangular beams does not equal the ultimate resistance of the material to tension or compression.

For instance, if a rectangular wooden beam be suspended at its ends and broken by a weight P placed at the middle, we have, from the formula which was deduced for this case in the preceding article,

$$R = \frac{3 P l}{2 b d^2}$$

in which all the quantities in the second member may be measured, and hence R may be found. Now, bearing in mind, that, in this case R is the ultimate resistance of a unit of fibres most remote from the neutral axis, and we would expect to find that it equals the force necessary either to pull asunder, or to crush a bar of the same material whose section is unity, when the force is applied in the direction of the length.

But an examination of tables, in which are entered the ultimate resistances to tension, compression, and values of R, shows that the disagreement is too great and too uniform to be attributed to errors of experiment. There is a very good table of this kind in the appendix of "Mosley's Mechanics and Engineering." A careful examination shows that the value of R is generally, indeed almost always, between the others. For instance, if the resistance to tension—which we will hereafter call S,—is greater than the resistance to compression—which we will call C;—then we find that R is less than S and greater than C. This is the case with wrought iron and most kinds of wood. If C be greater than S, R will be less than C and greater than S, as in the case of cast iron. We find the same result by comparing tables in Weisbach's Mechanics and Engineering.

Hence we infer *that the theory is not perfect; in other words, it does not represent the true law of resistance of beams.*

This fact induced Professor Barlow, a few years since, to investigate the law of resistance more carefully and more thoroughly than ever before; and as a result he announced a new law, called "*The Resistance to Flexure.*" I consider the term unfortunate; for all the resistances in a beam which resist bending may properly be called "*resistances to flexure*," but he intended to include only a certain class of resistances which he thought was developed by bending, and the value of which he tried to determine at the instant of rupture. I think it may more properly be called "*a resistance to longitudinal shearing.*"

He reported the results of his investigations to the Royal Society (England) in 1855, and afterwards published the data, experimental and analytical results upon which the theory is founded, in the *Civil Engineer and Architect's Journal*, vol. xix, page 9, and vol. xxi, page 111. They are also published in the *Journal of the Franklin Institute*, vol. xxxii, pp. 4 and 73. These articles from a scientific point of view, are looked upon as among the most valuable that have ever been written upon this subject.

His complete theory involves *two laws* of resistance; the *first* of which is essentially the same as that given in the preceding number.

19°; and the second of which he calls "*the resistance to flexure.*"

The first *law* includes, and is founded upon, the following principles:

1. The fibres on the convex side are extended, and those on the concave side are compressed.

2. There is a neutral surface, along which the fibres are neither extended nor compressed.

3. The resistance to extension and compression varies directly as the distance of the fibre from the neutral axis.

4. The ultimate resistance which acts along the most remote fibre is S on the side of tension and C on the compressed side: S being the tenacity of the material for a unit of section, and C the resistance to crushing per unit of section.

The second *law* is founded upon the following principles:

1. The *longitudinal shearing* is a resistance acting in addition to the direct extension or compression; and is really the cohesive resistance which is developed between two adjacent planes of fibres which are unequally elongated or compressed.

2. This resistance is evenly distributed over the transverse section; and, consequently, (within the limits of its operation) its centre of action on the compressed part will be at the centre of gravity of the compressed section; and, similarly, in respect to the extended part. This resistance per unit of section Barlow calls φ.

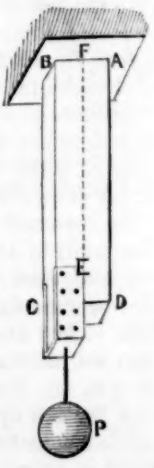
3. It is proportional to and varies with the *inequality* of strain between the fibres nearest the neutral axis and those most remote, and hence

4. The "resistances to longitudinal shearing" in open built beams will be to that in a solid beam of the same material at the instant of rupture, as the depth of the solid part, is to the distance of the outside of the solid part from the neutral axis.

5. Sections which were normal to the axis of the beam before flexure, will remain normal during flexure.

6. Rupture of solid beams will take place when the strain on a unit of section of the fibres most remote from the neutral axis, is $S + \varphi$ or $C + \varphi$, according as one or the other is first reached.

Fig. 30



To show more clearly the nature of the longitudinal shearing, I will refer to an example given by Barlow. Suppose that P, in Fig. 30, is just sufficient to pull asunder the bar F B C E, in which case it is supposed that all the fibres are equally strained, and each unit resists a force equal to S. Now if another bar, A B C D, were substituted for the former, and P applied to the same section, C E, it is evident that P would not break the bar; for the fibres just at the left of F E, will restrain those just at the right, so that they will not be elongated as much as they would if the part A F E D were removed. The restraining of the fibres just at the right of F E will have its effect upon the next plane of fibres, and so on to B C. Now this restraining influence, this cohesion between the

fibres is the "resistance to longitudinal shearing;" and it is evident that a portion of the force P, must be absorbed in overcoming it, so that it cannot produce a strain of S on the fibre B C.

A phenomenon similar to this takes place in a bent beam. The fibres unequally distant from the neutral axis are unequally strained, and hence develop the "longitudinal shearing;" and it seems evident that this strain absorbs some of the bending force. Hence, it takes a greater force to produce a strain S on the outer fibres, than it would if this resistance did not exist.

Although this theory seems rational, yet it remains to be seen whether it is the *true* one, or even whether it is better for practical purposes than the theory commonly used.

In analyzing it, we observe that all the resisting forces are parallel to the axis of X; and taking the applied forces parallel to the axis of Y, and we will immediately obtain equations (61) and (62); and hence the remarks which follow them apply to this theory.

I will now show how to develop the third of equations (62). Suppose that the beam ruptures on the side of tension. Let the origin be on the neutral axis; d_1 the distance of the most remote fibre from the neutral axis; and the other notation as in number 19°. Then proceeding as we did to obtain equation (65), and we find for the resistance according to the first law above named, $\frac{SI}{d_1}$; and according to the second law $\varphi\iint y dy dx$. Hence, the moment of resistance is,

$$\Sigma Fy = \frac{SI}{d_1} + \varphi\iint y dy dx \quad . \quad . \quad (84)$$

If the beam be rectangular, and the neutral axis at the centre of the section, b the breadth, d the depth, then $I = \frac{1}{12} b d^3$; $d_1 = \frac{1}{2} d$

$\int_0^b \int_{-\frac{1}{2}d}^{+\frac{1}{2}d} y\, dy\, dx = \frac{1}{4} b d^2$; and (84) becomes

$$\Sigma Fy = \frac{bd^2}{12}(2s + 3\varphi) \quad . \quad . \quad . \quad (85)$$

If the beam be supported at its ends, and P be applied at the middle; we have $\Sigma Fy = \frac{1}{4} Pl$, and (85) becomes,

$$2s + 3\varphi = \frac{3Pl}{bd^2}, \quad . \quad . \quad . \quad . \quad (86)$$

If $\varphi = 0$, equation (86) reduces to the *form* which is commonly used. It is evident that two experiments are necessary in order to determine both S and φ; but they can be more satisfactorily determined by taking a large number of experiments, and reducing the equations by the method of least squares.

If the theory be correct, the value of S thus found should be the same as that found by pulling a bar asunder by a force applied in the direction of its length. Barlow found for cast iron that $\varphi = 0{\cdot}85\, s$ for

a mean value; and for wrought iron $\varphi = \frac{1}{2}$ s nearly. (*See Civ. Eng. and Arch. Jour.*, vol. xxi, pages 114 and 116.)

This "longitudinal shearing resistance" not only has a value at the instant of rupture, but must act during all the stages of flexure up to the instant of rupture. The actual deflection therefore should be less than that found by the theory in common use; but as the observed deflections are generally small, no marked discrepancy between computed and observed results has, so far as I know, been detected.

21° *To find the position of the neutral axis.*

This may be found experimentally or analytically. The former has great advantage over the latter for any particular case, but the latter is essential for general purposes. The former must be resorted to, to confirm or vitiate a theory.

Position found by Experiment.—I will note a few examples where it has been determined experimentally.

Barlow made a very delicate experiment upon a solid rectangular cast iron beam, supported at its ends and loaded at the middle, in which he found the neutral axis to coincide exactly with the axis of the beam. (*See Civ. Eng. and Arch. Jour.*, volume xix, page 10.) He found the same result with a wrought iron beam under similar circumstances. (*See same Journal*, vol. xxi, page 115.) For malleable iron he found it to be $\frac{1}{4}$ or $\frac{1}{5}$ the depth of the beam from the compressed side. (*See Barlow's Strength of Materials*, page 330.) It should be observed that this experiment was made several years before the former ones, and that the means employed were not as delicate as in former examples. It is possible that a more careful experiment would show it to be nearer the centre of the sections than that given above.

A valuable set of experiments was made at the "Conservatorie des Arts et Méliers" in 1856, from which I infer, that in a wrought iron beam whose cross section is a double T, the neutral axis passes through or very near the centre of gravity of the sections. (*See Morin, Résistance des Matéraux*, page 137.) In the same work on pages 129, 130 and 131 are given the results of experiments upon rectangular wooden beams of various qualities, which show that it passes through or very near the centre of the transverse sections. So far as these examples are concerned the results are conclusive, and very strongly indicate that it generally coincides with or is very near the centre of gravity of the sections, when the deflecting force acts normal to the axis of the beam.

Position found by Calculation.—It is well known that within the elastic limits, the resistance of any fibre to extension is directly proportional to its elongation, and the latter is proportional to the modulus of elasticity. This is also true, to some extent, considerably beyond the elastic limit; but in the state bordering upon rupture it is not true, and it is difficult to measure the strains in any way so as to make them available for analytical purposes.

A. *Suppose that the deflecting forces are normal to the axis of the beam;* then we have only to develop the first of equations (61).

a. Let the strains upon the fibres be directly as their distances from the neutral axis.

I will first investigate those cases in which the elastic limits are not passed.

1. Let the modulus of elasticity for tension equal that for compression.

Let R_t = the strain upon a unit of fibres most remote from the neutral axis on the side of tension.

R_c = similar strain on the compressed side.

d_t = the distance of the most remote fibre from the neutral axis on the side subjected to tension.

d_c = similar distance on the compressed side, and other notation the same as before used.

The elongations of the fibres on one side of the neutral axis, equal the compressions of those on the other side which are equally strained; and because the strains are directly proportional to the distance of the fibres from the neutral axis, we have

$$\frac{R_t}{d_t} = \frac{R_c}{d_c} = s = \text{the strain at a unit's distance from}$$

the neutral axis; and at any distance y, the strain is $s\,y$;

$\therefore s\,y\,dy\,dz =$ the strain on any elementary fibre.

Hence after integrating once, we have $s\int_o^{d_t} zy\,dy$ which integrated so as to include the total extended part, gives the total tension. Similarly $\int_o^{d_c} zy\,dy$ gives the total compression. Observing that the angle between these forces is 180°, and we have by substituting in the first of (61)

$$s\int_o^{d_t} zy\,dy - s\int_o^{d_c} zy\,dy = 0$$

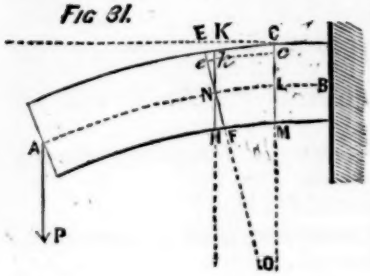
$$\text{or } \int_o^{d_t} zy\,dy + \int_{d_c}^{o} zy\,dy = \int_{d_c}^{d_t} zy\,dy = 0 \quad . \quad (87)$$

Now from the mechanics we know that the ordinate of the centre of gravity of any section is

$$\bar{y} = \frac{\int zy\,dy}{\int ydz},$$

and if the origin be at the centre of gravity, $\bar{y} = 0, \therefore \int zy\,dy = 0$, which is the same as (87). Equation (87) was obtained by taking the origin on the neutral axis; hence *the neutral axis coincides with the centre of gravity of the sections.*

Fig 31.



2. Let the moduli of elasticity be unequal.

Let E_t = the modulus of elasticity for tension,

E_c = the modulus of elasticity for compression,

y = N k = any ordinate, fig. 31,

$\lambda = k\,e =$ the elongation of the fibre at k,

dx = L N = the distance between two consecutive sections.

$dy\,dz$ = the area of a fibre,

p = the force which would produce an elongation or compression equal to λ of any fibre.

Let a beam be bent under the action of any number of parallel forces which are normal to its axis, so as to produce the neutral axis A N L B, Fig. 31.

Let C M and K H be two consecutive sections and normal to the neutral axis before flexure, then since they remain normal during flexure they will take the position of C M and E F, and will meet if produced in some point, as O.

Now, instead of the deflecting forces, we may conceive the beam to be severed along the plane K H and a force applied to each fibre acting in the direction of its length, those above L N elongating, and those below compressing the fibres, and each acting with such intensity as to produce the same elongations and compressions as the deflecting forces. Let p be one of the forces, producing an elongation or compression equal λ. We know that within the elastic limits, the force necessary to produce this elongation varies directly as the modulus of elasticity, the section and the elongation, and inversely as the length of the bar; hence,

$$p = \frac{E_t\,\lambda\,dy\,dz}{dx} \text{ or } = \frac{E_c\,\lambda\,dy\,dz}{dx} \quad . \quad . \quad (88)$$

according as it is tensive or compressive.

But because the sections remain normal to the neutral axis, we have from the similarity of triangles.

$$\frac{\lambda}{y} = c = \text{constant}, \quad . \quad . \quad . \quad (89)$$

equal the elongation or compression of a fibre at a unit's distance from the neutral axis.

$\therefore\ \lambda = c\,y$ which in (88) gives

$$p = \frac{c\,E_t\,y\,dy\,dz}{dx} \text{ or } \frac{c\,E_c\,y\,dy\,dz}{dx} \quad . \quad . \quad (90)$$

Hence the total tensive force is $\frac{c\,E_t}{dx}\iint_o^{d_t} y\,dy\,dz$

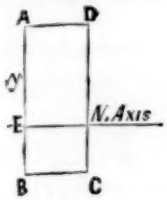
and the total compressive force is $\frac{c\,E_c}{dx}\iint_o^{d_c} y\,dy\,dz$;

hence the first of (61) becomes

$$E_t \iint_o^{d_t} y\,dy\,dz - E_c \iint_o^{d_c} y\,dy\,dz = 0 \qquad (91).$$

Equation (91) can be solved when the form of the section is known.

Fig 32



EXAMPLE.—Suppose the sections are rectangular, Fig. 32.

Let A D $= b$, A B $= d$,

$y =$ A E $=$ the superior limit,

$d - y =$ E B $=$ the inferior limit,

$\frac{E_t}{E_c} = r$, for convenience.

Take the origin at E,

Then (91) becomes $r \int_o^b \int_o^y y\,dy\,dz = \int_o^b \int_o^{d-y} y\,dy\,dz$

or $\frac{1}{2} r\,b\,y^2 = \frac{1}{2} b\,(d-y)^2$

$$\therefore y = \frac{d}{1+\sqrt{r}} \qquad (92)$$

If $r = 1$; $y = \frac{1}{2} d$,

$r = 0$; $y = d$,

$r = \infty$; $y = 0$.

If y is known, the ratio of the moduli are easily found; for by (92) we have

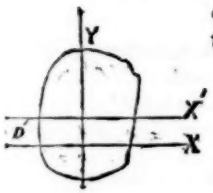
$$r = \left(\frac{d-y}{y}\right)^2 = \frac{E_t}{E_c}$$

Equation (91) is not so easily solved for the more complex forms.

3. To find the position of the neutral axis so as to give a minimum strength.

To solve this we have to make the first member of (65) a minimum.

Fig 33.



We assume that R is the same for all positions of the neutral axis. We have called I the moment of inertia about the line of intersection of the neutral plane and the section.

Let I' = the moment of inertia about an axis parallel to the former and which passes through the centre of gravity,

D = the distance between the axis,

A = the area of the section,

a = the distance of the most remote fibre from the axis which passes through the centre,

$d_1 = a + D$ = the distance of the most remote fibre from the neutral axis.

Then from the well known formula of reduction, we have

$$I = I' + D^2 A.$$

Hence, the first member of (65) becomes

$$\text{R}\frac{\text{I}}{d_1} = \text{R}\frac{\text{I}^1 + \text{D}^2\,\text{A}}{a + \text{D}} \quad . \quad . \quad . \quad (93)$$

which is to be a minimum. Observing that I^1, a, D, and A are constants; and differentiating, placing equal zero and solving, gives,

$$\text{D} = -a \pm \sqrt{a^2 + \frac{\text{I}^1}{\text{A}}} \quad . \quad . \quad (94)$$

The positive value of D makes the second differential co-efficient positive; hence, it is the minimum; and the negative value is the maximum. The maximum value is really the minimum of the negative values.

EXAMPLES.—1. Suppose the sections are rectangular. Let d be the depth, and b the breadth.

Then $a = \frac{1}{2}d$; $\text{I}^1 = \frac{1}{12}b\,d^3$; $\text{A} = b\,d$,

which in (94) gives

$$\text{D} = \begin{cases} +\,0{\cdot}07732d \\ -\,1{\cdot}07732d \end{cases}$$

The positive value in (93) gives $\text{R}\,\frac{\text{I}}{d_1} = 0{\cdot}1547\,\text{R}\,b\,d^2$. . (95)

If the neutral axis passes through the centre of the sections, $\text{D} = 0$ and (93) gives $\frac{1}{6}\,\text{R}\,b\,d^2 = 0{\cdot}1666\,\text{R}\,b\,d^2$. . . . (96)

2. Suppose the sections are circular.

Then, $a = r$; $\text{I}^1 = \frac{1}{4}\pi r^4$; $\text{A} = \pi r^2$

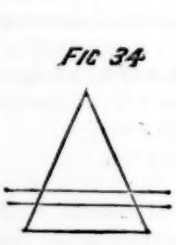
$$\therefore \text{D} = \begin{cases} +\,0{\cdot}11807\,r \\ -\,1{\cdot}11807\,r \end{cases}$$

$$\text{and } \text{R}\frac{\text{I}}{d_1} = 0{\cdot}7415\,r^3\,\text{R}.$$

If the neutral axis passes through the centre of gravity of the sections $\text{D} = 0$ and (93) becomes

$$\text{R}\,\frac{\text{I}}{d_1} = 0{\cdot}7854\,r^3\,\text{R}$$

FIG 34



3. Let the sections be isosceles triangles, Fig. 34.

Let d = the altitude, b = the base.

Then, $a = \frac{2}{3}d$; $\text{I}^1 = \frac{1}{36}\,b\,d^3$; $\text{A} = \frac{1}{2}\,b\,d$

$$\therefore \text{D} = 0{\cdot}0403\,d$$

$$\therefore \text{R}\,\frac{\text{I}}{d_1} = 0{\cdot}04043\,d$$

If $\text{D} = 0$ we have $\frac{\text{RI}}{d_1} = 0{\cdot}04166\,d$

This analysis leads to some interesting considerations. According to the second hypothesis it appears that the neutral axis will be nearer the side which has the greater modulus of elasticity. That is, if the modulus for compression is greater than for tension, the neutral axis will be nearer the compressed side. But the modulus for compression is nearly the same as for tension in all the materials with which the

engineer has to deal; hence, so long as the elasticity is unimpaired, the neutral axis passes *very near* the centre of the sections. But as the strains are increased, and the elasticity becomes impaired the third hypothesis shows that the neutral axis moves from its original position towards the side which offers the greatest ultimate resistance to the strain, until, at the instant of rupture, the distance between the centre and neutral axis is D, equation (94).

The latter reasoning furnishes an amusing paradox; for if, in a rectangular beam, we suppose that the ultimate resistances to compression and tension, as well as the moduli of elasticity, are exactly equal, it follows that both sides of the beam would be equally impaired by the strains; and hence, the neutral axis could not move, but must remain at the centre, in which case, the beam would be stronger than if one of the resistances were slightly increased.

The relative strength of the beam in the two cases is shown by equations (95) and (96). The paradox is purely theoretical, for no material is so perfectly homogeneous as to realize the conditions upon which it is founded.

If a rectangular beam be supported at its ends and is broken by a weight P, applied at the middle, we know that the moment of the weight is $\frac{1}{4}Pl$; and this must equal the moment of resistance; hence we have,

according to equation (95) $0{\cdot}1547\ Rbd^2 = \frac{1}{4}Pl$ (97)

" " (96) $0{\cdot}1666\ Rbd^2 = \frac{1}{4}Pl$ (98)

We see that the same general law holds in these equations; viz: that the resistance of a rectangular beam varies directly as the breadth and square of the depth, and inversely as the length.

We have supposed that R is constant, and hence must be determined by means which are independent of any theory of transverse resistance, unless we succeed in establishing the true theory; for each theory gives a value peculiar to itself.

Thus, in equations (97) and (98), all the quantities except R may be found by direct measurement and R found by simple computation; but the two equations give different values. It makes no difference which equation is used, provided we use the same one in practice that we do for obtaining the value of R; but unless the theory be correct R must be determined for each form of beam used in practice. When the true theory is established, it will give the same value for the constants in all forms of beams which are made of the same material.

I am not aware that the last hypothesis has been investigated before, and I have not now the time to apply it to experiments to see if it possesses much merit. A glance at it, however, inclines me to the opinion that it possesses little or no advantage either theoretically or practically over the commonly received hypothesis which fixes the neutral axis at the centre of the sections. In connexion with Barlow's theory it may be found to be of great value. In my next I will develop the formulas which will be applicable to the case.

(To be continued.)

MECHANICS, PHYSICS, AND CHEMISTRY.

Experiments on the Trompe.

From the London Mechanics' Magazine, October, 1864.

The trompe is a species of blowing machine, which is used in mountainous countries for producing a blast of smelting operations. As now constructed it consists of a large cistern, from the bottom of which proceed two vertical tubes about 20 feet long; the lower ends of the tube pass into a wooden wind chest, furnished with a blast pipe for the exit of air, and also with an arrangement for keeping water within at a constant level. Immediately below the point where the tubes enter the water cistern each tube is constricted, and a few inches beneath the constriction several holes are bored in the circumference of the tubes, so that air may have free access to their interior. When water is allowed to fall from the water cistern through the tubes, a quantity of air is carried down by the descending stream, which air separates from the water, as soon as it has entered the cistern, and rushes from the blast pipe in a continuous current.

In the *Philosophical Magazine* for last month, Mr. Rodwell has detailed a number of experiments which he made in order to determine "the most favorable conditions under which air is carried down by a stream of water, and to arrive at a satisfactory explanation of the cause of the descent of air in the different modifications of the trompe."

In regard to the etymology of the word, Grignon ("Memoirs de Physique sur l'art de fabriquer le fer, d'en fondre et forger des Canons d'artillerie, &c.") states that the trompe received its name from the fancied resemblance to a water spout. Landais derives trombe (of which trompe is the old French form) from στρόμβος, a top, a spindle, a round shell, which in its turn is derived from στρόφω, to turn, twist, revolve. The author conceives that the trompe received the same name as water spout, "either because of the mixed column of air and water produced in certain forms of the machine, or more probably from the whirling motion of the water around a conical cavity," which would occur in many of the old forms of the trompe; in both these respects there is a resemblance to a water spout.

The second section of the paper is devoted to the description of an instrument by means of which the amount of air carried down by a stream under various conditions can be determined with accuracy. Several tables of experiments made with this instrument are given, which show the amount of air carried down by half a litre of water, under various conditions of pressure, velocity, &c., and flowing from *a*, a circular, *b* rectangular, *c* square, and *d* triangular discharge tube. The constituent of a jet of liquid moving downwards with great velocity is considered, and it is stated that when such a stream falls through a vertical tube, the area of the cross section of which does not exceed a certain dimension in relation to that of the orifice from which the liquid flows, disks of water are produced in the tube, which are pushed down by the descending stream, and force down the air beneath them.

If, on the other hand, the pressure on the lower orifice of the vertical tube is competent to support a column of water at a certain height in the tube, the descending stream comes into direct collision with the water, and air is then carried beneath the water surface on account of the formation (by the descending masses of water) of cavities, into which air enters, according to the theory of Professor Magnus, of Berlin.

The author gives the following example to illustrate this mode by which air is carried beneath the surface of the liquid:—"We have a frequent example of this action of detached fluid masses. If we wish to pour out beer so that it shall have no froth, we pour it down the side of the glass, the adhesion of which flattens the stream into a ribbon, and it enters the fluid in the glass slowly. There is no falling of detached masses here, consequently no air is carried down. On the other hand, if we wish to produce froth, we pour out the beer from as great a height as possible, and the masses detached by the accelerating force of gravity carve out channels in the liquid, into which air enters and is carried down, and afterwards rises to the surface in bubbles."

A small lead shot weighing ·072 gramme was found to cause 192 times its own volume of air to penetrate beneath the surface of water by being thrown into it for a height of 1½ feet at an angle of 60°.

The greatest amount of air which the author found to be carried down by a stream of water flowing from a delivery tube 3-20ths of an inch diameter through a vertical tube 21-60ths of an inch diameter at the rate of half a litre in 34 sec. was—*a*, by disk action, 615 c.c.; *b*, by direct collision, 182 c.c. per half litre of water.

We have all noticed the whirling conical cavity which forms over an orifice in the bottom of a vessel from which a liquid is escaping. If rotatory motion is given to the liquid before it commences to flow, the cavity forms at a considerable height about the orifice, and air enters through it and makes its way into the issuing stream. This is discussed in the third section of the paper. The author found more air to be carried down by this means than by any other. Water flowing from a tube 13-120ths of an inch diameter at the rate of half a litre in 39 seconds, carried down no less than 1392 c.c. for each half litre of water. "Stated in other words, a little stream of water about 1-10th of an inch in diameter at the orifice from which it issues, with a head of water of two feet, carries down in one hour 128 litres of air."

Let us suppose a continuous vertical tube less than 33 feet long in connexion with a water cistern, and moreover that water is flowing through the tube into a vessel containing water; if we close the orifice in the cistern from which the water issues, a column of water will remain suspended in the vertical tube by atmospheric pressure. Now let an orifice be made anywhere in the circumference of the tube, and the column of water beneath that orifice will immediately fall, because the atmospheric pressure below the orifice is at once neutralized, and the water descends by its own weight. If we again cause water to

flow through the tube, the column below the lateral orifice will obviously have greater velocity than that above it; hence rupture will ensue at the orifice, and air will enter, the flowing water will momentarily close the orifice, air will again enter, and so on.

The fourth section of the paper, is devoted to the carrying down of air by this mode, and the author found that half a litre of water flowing from a delivery tube 3-20ths of an inch diameter carried down 320 c.c. of air.

In the fifth section Mr. Rodwell gives a summary of the investigation; this we give verbatim:—

"We see from the above that there are four modes by which air can be carried down by a stream of water falling through a tube.

"1. If the area of the cross section of the tube through which the water falls be not much greater than that of the orifice from which the water flows, disks will be formed in the tube, and being pushed down by the descending stream, will force down the air beneath them.

"2. If the area of the cross section of the tube through which the water falls, be much greater than that of the orifice from which the water flows, so that disk action is prevented: or if the pressure on the lower end of the tube be competent to support a column of water in the tube at such a distance from the orifice from which the water flows that the descending stream has not widened sufficiently to allow of the formation of disks, air will be carried beneath the water surface on account of the formation of cavities, according to the theory of Magnus.

"3. If there is not a great depth of water in the vessel which supplies the descending stream, or if (the depth not of necessity being small) rotatory motion from any cause imparted to the water, air will enter through a cavity formed above the orifice from which the descending stream issues, and extending into the descending stream.

"4. If the area of the cross section of the orifice from which the water flows be as great, or nearly as great, as that of the tube through which the water falls, and if at the same time the orifices for the admission of air do not exceed a certain area compared with that of the orifice from which the water flows, air will enter at the rupture of the steam, produced at the orifices, by the accelerated motion of the water below those orifices.

"The cause of the descent of air in the different modifications of the trompe is not due to any one action of a stream of water; air is carried down by all four of the modes of action mentioned above.

"Generally only one mode obtains in one form of the machine; but there may be two modes acting simultaneously, the particular mode or modes being determined, *a*, by the relation of the area of the cross section of the trompe tube to that of the orifice from which the stream flows; *b*, by the head of water above the orifice from which the stream flows; *c*, by the fact of whether there are causes which induce rotatory motion in the water before it leaves the cistern; *d*, by the form of the orifice from which the stream flows; *e*, by the manner in which air is allowed access to the interior of the tube; and lastly, *f*, by the amount of pressure on the lower orifice of the tube.

"The first and fourth modes least seldom obtain; the second obtains in the generality of modern trompes; and the third obtains in the trompe described by François, in trompes with very shallow cisterns, in trompes in which water before leaving the cistern receives rotatory motion, either from the stream which supplies the cistern entering at an angle to the water surface, or from some other cause, and in all trompes with inclined tubes (of which, as above stated, Kircher had seen forty prior to the year 1655).

"I consider the most economical, and in every way the most efficient form of trompe, to be the old form, in which there are no air-holes, and the air enters by a conical cavity in the water above the orifice from which the descending stream issues. It will be seen from the above that by this method we obtain nearly double the amount of air obtainable by other means. The construction of such a trompe, moreover, is comparatively easy; there is no need to have the tubes perfectly vertical, and less spray is carried into the furnace than by the form of trompe now in use."

On Chemistry Applied to the Arts. By Dr. F. Crace Calvert, F.R.S., F.C.S.

From the London Chemical News, No. 241.

Continued from page 256.

Gelatine, Glue, Bone-size, Chondrine, their preparation, chemical properties, nutritive value, and application to arts and manufactures. Artificial tortoise-shell. *Isinglass*, its adulterations and adaptations to the clarification of fluids. *Skins* and the art of tanning.

Lecture II.

Delivered on Thursday evening, April 7, 1864.

As the syllabus will show you, I intend to draw your attention, especially in this lecture, to gelatinous substances, as well as to the art of tanning. There are four distinct gelatinous substances obtained on a commercial scale from animal tissues and bones, viz:—*Osséine*, which I mentioned in my last lecture, *Gelatine*, *Chondrine*, and *Isinglass*.

Osséine, as already stated, is the animal matter existing in bones, and no doubt it is the same substance which also exists in skins, both during life and when recently removed from the animal. It is characterized by its insolubility, its inability to combine with tannin, and lastly, the facility with which it undergoes a molecular change, and becomes converted into gelatine, slowly, when boiled with water at 212°, rapidly, when boiled under a pressure at a higher temperature, and very gradually under the influence of putrefaction.

Gelatine is a solid semi-transparent substance, which absorbs water in large quantities (40 per cent.), becoming thereby transparent. It is very slightly soluble in cold water, but very soluble in boiling water, and this solution has the characteristic property of forming a jelly on cooling. So powerful is gelatine in solidifying water, that one part of gelatine will form a jelly with 100 parts of water. It has been observed that gelatine loses this valuable property if boiled for a lon

time at ordinary pressure, or if carried to a temperature above 223° F. Before examining the interesting action of acids upon gelatine, allow me to mention that whilst solid gelatine resists putrefaction for a long time, its solutions have a tendency to putrefy rapidly, but I have the pleasure to inform you that a few drops of a substance called carbolic acid will prevent putrefaction for a long period. Gelatine dissolves rapidly in acetic acid, of moderate strength, or vinegar, and this solution, which is used as glue, has the useful property of remaining fluid and sound for some time. But a Frenchman, named Demoulin, has introduced of late years in Paris a solution of glue which is superior to the above and to that in common use, because it does away with the trouble of constantly heating the glue-pot. His process consists in melting one pound of best glue in one pound of water, and adding gradually to the two one ounce of nitric acid of sp. gr. 1·36, heating the whole for a short time, when the fluid glue is prepared. The action of concentrated nitric acid on gelatine is most violent, giving rise to several compounds, amongst which may be cited oxalic acid. The action of sulphuric acid on gelatine is important in a scientific point of view, as an alkaloid called leucine is produced, as well as a sweet substance, called glycocolle, or sugar of gelatine. Gelatine is distinguished from other organic substances by the following chemical reactions:—it gives a white precipitate with alcohol, also with chlorine, none with gallic acid, but one with tannin, or tannic acid. The properties of this precipitate are most important to us, as it is on the formation of it in hides that we ascribe their conversion into leather. The relative proportion of these two substances (gelatine and tannin) in the precipitate varies with the respective proportions brought in contact, but precipitates containing as much as 46 per cent. of tannin have been examined. It is insoluble in water, and presents the invaluable character of not entering into putrefaction. Beautiful fancy ornaments have recently been introduced in Paris by M. Pinson, called artificial tortoise-shell, which he obtains by melting at a moderate temperature, gelatine with a small amount of metallic salts, running the whole into moulds, staining the mass with hydro-sulphate of ammonia, so as to produce an imitation of the grain of tortoise-shell. The objects so produced are then polished and ready for sale. Before entering on the manufacture of various qualities of gelatine, I should wish to state that there can be no doubt, from the researches of Magendie, as well as from the Report of the Commission appointed by the Netherlands Academy of Sciences that gelatine as food possesses no nutritive value whatever. Allow me now to give you a rapid outline of the methods followed in the manufacture of various qualities of gelatine. The first quality of gelatine is prepared by taking the clippings, scrapings, and fleshings from the tanyard, treating them with lime water or alkali, to remove any smell and certain impurities. They are then well washed and left in contact for a day or two with a solution of sulphurous acid. They are then placed in a suitable apparatus with water, and heated, when the osséine is converted into gelatine. This is run into a second vessel, and a little alum added, to throw down any impurities that may be in sus-

pension. The liquor is now ready to be run into another pan, where it is concentrated to the necessary consistency, so as to become solid when it is run into wooden moulds. Eighteen hours afterwards the gelatine is turned out of these moulds on to a wet slab, where it is cut into slices by means of a copper wire; these slices are placed on wire gauze frames, and left in a drying shed until they are perfectly dry and ready for the requirements of trade. The second quality of gelatine is prepared by placing bones in large cylinders, and allowing high-pressure steam to arrive at the bottom of the cylinder, which rapidly converts the osséine of the bones into gelatine, and the removal of this is facilitated by allowing a stream of hot water to enter the upper part of the cylinder. The solution of gelatine thus obtained is evaporated, and is usually employed for the preparation of glue. A third quality is prepared by treating bones with hydrochloric acid (as referred to in my first lecture), and submitting the osséine thus obtained to the action of steam. Lastly, a fourth quality of gelatine, called bone-size, is manufactured by boiling more or less decayed bones, as imported from South America and elsewhere, the flesh of dead animals, &c., and concentrating the solution to the consistency required for the various applications it receives in commerce. [The lecturer then described the mode of obtaining the beautiful thin colored sheets of gelatine used in photography and other fancy purposes, and also the characteristics which distinguished good from bad glues.]

Chondrine, or cartilage gelatine, first noticed by Messrs. Müller and Vögel, jun., is interesting as possessing qualities, not only different from those of gelatine, but such as injure the quality of the latter when mixed with it. In fact, it gives precipitates with acetic acid, alum, persulphate of iron, and other salts; and as gelatine is often used in connexion with these substances, it is easy to foresee how these precipitates may interfere with its application. On the other hand, the quality possessed by this peculiar gelatine, may, I think, render it serviceable in the art of calico printing, for fixing colors, or as a substitute for albumen or lactarine. Thus, the solution of chondrine and acetic acid may be mixed with any of the new tar colors, and the whole printed, allowed to dry, and steamed; the acetic acid will be driven off, leaving the color fixed by the chondrine on the fabric. Chondrine is prepared by submitting to the action of heat and water the cartilaginous tissue of animals, or the bones of young animals.

Isinglass is obtained from the air-bag or swimming-bladder of several kinds of fish, especially those of the sturgeon tribe, and, although imported from various parts of the world, the principal supplies are from Russia, from whence the best qualities come, which bear the names of Beluga, Volga, or Caspian Sea leaf. Brazil, New York, the East Indies, and Hudson's Bay also supply various qualities of this valuable substance. It also reaches this country in different states, viz: in leaf and in honey-comb, that is, the bag is cut open, cleaned and dried; and the quality called snow-bleached is enhanced in value by having been buried in the snow on the banks of the Volga for a

long period, by which the isinglass is whitened. Pipes, purses, and lumps are bags which have been cleared but not opened; and a quality called ribbons is made by rolling the bag and cutting it into strips before shipping it to this country.

I shall now endeavor to explain to you how the beautiful preparations before you, for which I am indebted to the kindness of Mr. Jas. Vickers, are obtained. The leaf bladder is first softened in water, and rolled out, under high pressure, into thin leaves, which may extend to several feet long; these in their turn are drawn under a number of revolving knives, making 1000 revolutions per minute, by which 6000 of the well known fine threads are produced in every minute. This quality is chiefly used for culinary purposes. For commercial uses the purses or lumps above mentioned are chiefly employed. These are soaked in water for two or three days, cut open, certain useless parts removed, further softened, rolled and cut into various dimensions, according to the requirements of trade, their chief use being the clarification of beer and other alcoholic fluids for which gelatine cannot be employed, because it dissolves in water, whilst isinglass merely swells. The result is that the highly swollen and extended mass, when poured into beer, wine, or other alcoholic fluids, is on the one hand contracted by their alcohol, and on the other hand it combines with their tannin, forming an insoluble precipitate, which, as it falls through the liquor, carries with it the impurities in suspension, and thus clarifies the fluid. As isinglass is very slow in swelling out in water, brewers employ an acid fluid for the purpose, but, strange to say, instead of using pure acetic acid, many of them take sour beer, and thus run the great risk of spoiling their sound beer. I have known instances of great losses occurring in this way, acetous fermentation having been thus spread through an entire brewery during the summer months. As a large quantity of gelatine, cut into shreds, in imitation of isinglass, is sold at the present day, it may be useful to know that detection is very easy by the following method:—Place a small quantity in hot water, in which gelatine will readily dissolve, whilst isinglass will do so very slowly. I cannot conclude the examination of this interesting class of substances without drawing your attention to the fact that osséine, gelatine, chondrine, and isinglass present marked differences in their textures and general properties, although their chemical compositions may be considered identical, thus:—

	Osséine.	Gelatine.	Chondrine.	Isinglass.
Carbon, .	50·4	50·0	50·61	50·56
Hydrogen, .	6·5	6·5	6·58	6·90
Nitrogen, .	16·9	17·5	15·44	17·79
Oxygen, .	26·2	26·0	27·37	24·75

Esculent Nests.—I must not omit to mention, in connexion with this interesting class of substances, these curious gelatinous products, which are not only considered great delicacies in China, India, but even in Europe, where they realize from £3 to £7 per pound; considerable quantities are imported into England. It has long been a disputed question what is the chemical nature of the substances compos-

ing these nests, which are the product of a peculiar kind of swallow; but Mr. Payen, by his recent researches, has left no doubt in the minds of chemists that it is an animal, not a vegetable matter. In fact, it is a peculiar mucous substance, secreted by the bird, and composed of carbon, hydrogen, oxygen, nitrogen, and sulphur. Further, it is insoluble in cold water, but soluble in boiling, and differs from gelatine and isinglass in that it does not gelatinize as it cools.

Skins.—Skin consists of two principal parts, one a mere film, called the epidermis, and the other constituting the bulk of the skin, and called the dermis. There are also found in skin a large quantity of blood-vessels, and a small quantity of pigment cells, which hold the coloring matter. Further, the skin contains a small amount of nerves and a number of glands, among which may be cited the sebaceous glands or follicles, which are intended to secrete the unctuous matter constantly accumulating upon the skin, and keeping it soft and pliable; then there are the perspiratory glands, which play a most important part in the physiological construction of the skin. These are so numerous that Mr. Erasmus Wilson has calculated that there are 3528 of them in a single square inch of human skin, so that in an ordinary sized body there are no less than 2,300,000 of these pores. But still the most important part of the hide for us is that called the "dermis." The skins of animals are commercially divided into three distinct classes. The hide is the name given to the skin of full-grown animals, such as oxen, horses, and buffaloes; and these are further sub-divided into fresh hides, that is to say, those which are obtained from animals slaughtered in this country; dry hides, that is, hides which have been dried in the sun, and which are principally imported from South America; dry salted hides, principally from the Brazils, where they are salted and then dried in the sun; and salted hides, which are preserved in Monte Video and Buenos Ayres by salting them, and which are shipped, embedded in salt, to this country. The composition of a fresh hide may be considered to be as follows:

Real Skin, ...	32·53
Albumen, ...	1·54
Animal matters soluble in alcohol, . .	0·83
Animal matters soluble in cold water, .	7·60
Water, ...	57·50
	100·00

A second class of hides is that called kips, which are skins flayed from the same kinds of animal as the foregoing, only when young. Thirdly, the term skin is applied to those of small animals, such as the sheep, goat, seal, &c.

I will now endeavor to give you an idea of the preparation which hides undergo to fit them for the art of tanning. These operations are four. The first consists in washing off the dirt from the hide, softening it, if a dried one, or removing the salt, if salted. The second has for its object the removal of the hair, which is effected by two or three different methods. The most usual plan is to place the hides in

large vats, containing a weak milk of lime, for two or three weeks, care being taken to remove and replace them every other day, after which time the hair is sufficiently loosened to be removed. A second plan consists in piling up the hides, allowing them to enter slightly into a state of putrefaction, and then placing them in weak milk of lime, so as to complete not only the loosening of the hair, but also the swelling of the hide, for lime also possesses that property. Another process, called the American plan, is to hang the hides in pits for two or three weeks, keeping them at a temperature of 60°, and constantly wet, when the hair can be easily removed. Weak alkalies are sometimes substituted with great advantage for lime in the above processes, and this plan is certainly the best, as it does not leave in the hide any mineral residue, as is the case with lime, either in the form of an insoluble soap of lime or of carbonate, both of which are highly objectionable in the subsequent process of tanning, as they act on the tannic acid of the tan, facilitating its oxidation, and thereby rendering it useless. Depilation of hides is sometimes effected by the employment of weak organic acids; thus, the Calmuck Tartars have used from time immemorial sour milk for that purpose. In some parts of France, Belgium, and Germany, the unhairing of the skins is also effected by an acid fluid, produced by the fermentation of barley meal, which gives rise to acetic and lactic acids. To carry out this process, generally speaking, five vats are used. In the first the hides are cleaned; in the second they are softened, and the hair and the epidermis prepared for depilation; and the third, fourth, and fifth are used to swell and give body to the hide. This operation, which is called white-dressing, does not work so well as lime for heavy hides, as it swells them to such an extent as to render them unfit to prepare compact leather. When the hair can be easily pulled off, the hides are placed on a convex board called a beam, and scraped with a double-handed concave knife, which not only removes the hair, but a large amount of fatty lime-soap and other impurities from the hides. The third operation consists in fleshing the hides, by shaving off all useless flesh, fat, and other matter by means of a sharp tool. The fourth operation is called swelling or raising the hide, the purpose of which is the following: First, the removal of any lime or alkali which may remain in the hide; and secondly, to swell or open the pores of the hide, so as to render them better adapted to absorb the tannic acid of the tanning liquors. This is effected by dipping the hides in weak spent tanning liquors, or liquors which have lost their tannic acid, but which contain more or less of gallic acid, for not only do all tanning matters contain gallic acid, but its proportion is greatly increased during the operation of tanning, by a process of fermentation which goes on during that operation, and which converts tannic acid into gallic acid and a peculiar sugar.

The Tanning of Hides.—The old process of tanning consisted in placing layers of wet tan and of hides alternately, and after two or three months removing the whole from the pit and replacing the old by fresh tan. These operations were repeated until the hides were tanned, which took from eighteen months to two years, owing to the

difficulty of the tannic acid reaching the interior of the hide. Of late years the process of tanning has been greatly shortened by treating the bark with water, and steeping the hides in the liquor, first weak and afterwards strong. By this means good leather can be obtained in the space of eight or ten months. More rapid tanning, but probably giving inferior leather, is effected by employing, in conjunction with, or as a substitute for, bark, a decoction of dividivi, valonia, myrobalan, catechu or terra japonica, gambir, &c. Many efforts have been made of late years to apply the laws of hydraulics, as well as several physical and physiological principles discovered by eminent philosophers, with the view of shortening the period of tanning, but as I believe that none of them have received the general sanction of the trade, I shall confine myself to giving you an idea of the most successful ones. The first attempt to accelerate the process of tanning consisted in forcing the tannin fluids into the substance of the hide by means of hydraulic pressure. Mr. Spilbury, in 1831, employed a process which consisted in making the hides into sacks, and plunging them into a tanning liquor, and as the fluid percolated through the skin into the interior of the bag the air was allowed to escape. By this means a certain amount of time was saved in bringing the tanning liquor in contact with the various parts of the skin. Mr. Drake soon followed in the same direction, his plan being to sew hides together, forming bags, which he filled with a solution of tan; and to prevent the distention of the skins by the pressure of the liquid within, they were supported in suitable frames; as the pores became gradually filled with tannin, artificial heat was applied to increase the percolation of the fluid. Messrs. Chaplin and Cox's process is also very similar to the above, the difference being that the tannin fluid is placed in a reservoir, and allowed to flow into the bag of hides through a pipe, the fluid being thus employed at pressures varying according to the height of the reservoir. The bag of hides is at the same time plunged into a solution of tannin to prevent excessive distension. Messrs. Knowles and Dewsbury have recourse to another principal to compel the percolation of the tannin liquor through the hide. To effect their purpose they cover vessels with hides, so as to form air-tight enclosures, and, having placed the tannin fluid they employ on the hides, the vessels are exhausted of air, and atmospheric pressure then forces the fluid through the skins into the vessels below. Mr. Turnbull's process, being an imitation of that used for tanning Morocco leather, need not be described. Attempts have been made from time to time to mineralize hides, that is to say, to substitute for tanning, mineral salts, as will be described in my next lecture, when speaking of the art of tawing skins. The processes which have attracted most notice in this branch of the art of preparing leather are those of Messrs. D'Arcet and Ashton, M. Bordier, and M. Cavalier. M. Bordier's plan is that of dipping hides in a solution of sesquisulphate of iron, when the animal matters of the hide gradually combine with a basic sesquisulphate of iron, rendering the hide imputrescible, and converting it into leather. M. Cavalier's method is to dip hides first into a solution of

protosulphate of iron, and then into one containing alum and bichromate of potash. A chemical action ensues, by which the protosulphate of iron is converted into a persulphate, combining with the animal matter, and by its preservative action, together with that of some of the alum, the hide is converted into leather. I think, however, that I shall be able to satisfy you, from the results of many examinations of leather and hides which I have made, that there are good and sufficient reasons why most of these processes have necessarily failed. Inventors have been led to believe, by the statements of many eminent physiologists, (as can be proved by reading some of the most recent works on that science), that skin is composed of blood-vessels, glands, &c., plus gelatine, and that if by any mechanical contrivance the tanning liquor could be brought into contact with this gelatine, the leather would be tanned; and many ingenious schemes have been devised, and much money expended, to obtain that result. The fact, however, is that there is no gelatine in skin, for if there were, when hides were placed in water, the gelatine would be dissolved and washed away. But what is supposed to be gelatine in the hides is in reality the isomeric substance called osséine, or one greatly resembling it. The great discovery to be made in the art of tanning, therefore, is that of a chemical or fermentative process, by which the isomeric change (that of the osséine into gelatine) may be rapidly produced, instead of by the slow putrefactive process which occurs in the old method of tanning. Further, I would observe that to convert a hide into leather it is not sufficient that the whole of its animal matter be combined with tannin, for the leather thus obtained would present two great defects; 1st, the hide would not have increased in weight, and the tanner's profits, therefore, would suffer; 2dly, the leather would be so porous as to be useless for many of the purposes for which leather is required. The reason of this is, that when, after a period of several months, the osséine has been converted into gelatine, and this has become thoroughly combined with tannin, a second series of reactions is necessary to render the leather more solid and less permeable to water, and to increase materially its weight. These reactions constitute what is called feeding the hide, and are brought about by leaving it to steep in more concentrated tanning liquor for a considerable period; and this necessary process, beneficial to the wearer as well as to the producer, appears to me to be that which offers the greatest impediment in the way of shortening the period of tanning. The hides as they leave the tanning vat require several operations before they are ready to be used for soles, or to be curried for various commercial purposes. They are first slightly washed and placed in a shed to partially dry, and are then rubbed with a brush and rough stone on the face of the leather, or hair side, to remove any loose tanning material that may remain on the surface; but this rubbing is not applied to the back, as buyers attach great importance to the peculiar appearance called the bloom, which enables them to judge of the goodness of the tanning. The tanned hides are again slightly dried, and oiled on the face, and then submitted to the pressure of a roller passed over the surface,

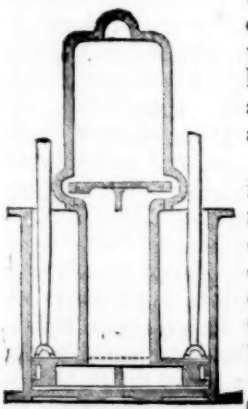
which has the effect of rendering the leather more flexible, and the surface perfectly uniform. These operations are repeated two or three times, when the leather is ready for soles. Before the tanned hides intended for shoe-soles are considered fit for that purpose, they must be slightly compressed and softened, so as to again diminish their permeability to water. This was formerly effected by beating with a hammer called the mace, but of late years this slow process has been superseded by compressing machines; and I believe those most appreciated in the trade were invented by Messrs. Cox and Welsh, and Messrs. Iran and Schloss.

To be Continued.

Lake's Differential Steam Engine. By Francis Campin, C. E.

From the London Artizan, March, 1865.

Sir:—In the differential steam engine, of which the annexed diagram exhibits a vertical section, great simplicity of construction is achieved, in addition to increased economy in consumption of steam. The engine comprises two cylinders of different diameter, so arranged as to be axially in the same straight line; these cylinders are furnished with pistons, as shown in the sketch, that in the small cylinder being perforated round its periphery between the packing rings. The interior of the piston communicates with a trunk or chamber which connects it to the large piston in the expansion cylinder, which is open at the bottom. When the small piston is at the bottom of the stroke, as illustrated, the holes in its periphery correspond to others in the curved lateral steam passages, of which the other ends open into the cylinder a little higher up, and through which steam from above the small piston flows, filling the trunk and space below the large or expansion piston.



Let us now examine the effect of the working of the engine, assuming the following dimensions: Diameter of small cylinder 8 ins.; of large cylinder 16 ins.; stroke 1 foot; cubic contents of trunk equal those of the small cylinder; pressure of steam above the atmosphere, 60 lbs. per square inch, or absolute pressure, 75 lbs. per square inch.

The effective area of the small piston may be taken as 50 square inches; that of the large piston being four times as much, or 200 square inches. First we will consider the work done in the down stroke through which the steam acts on the small piston with its full force: we have 50 square inches $\times$ 75 lbs. per square inch $\times$ 1 foot = 3750 foot lbs.; the useless resistance is the atmospheric pressure, or 50 square ins. $\times$ 15 lbs. $\times$ 1 foot = 750 foot lbs., which, deducted from the gross work, leaves as effective work 3000 foot lbs. done during the down stroke. In the up or expansion stroke, the steam supply is cut off as soon as the small piston

has repassed the ends of the lateral steam passages, and then the steam in the trunk continues to expand during the remainder of the stroke; and because the large cylinder is four times the size of the trunk, (of which the contents equal those of the small cylinder,) it is evident the steam will expand five times, or down to a pressure of 15 lbs per sq. inch absolute; for that quantity of steam which at the commencement of the stroke filled only the trunk, will, at the end of the same stroke, fill the trunk, and in addition thereto the large cylinder. The mean pressure in the up stroke will therefore be about 45 lbs. per square inch; so the gross work done by the steam in the up stroke will be 200 square ins. × 45 lbs. × 1 foot = 9000 foot lbs. From this must be deducted the prejudicial resistances: first, there is the whole pressure of steam on the small piston (for the small cylinder is always in communication with the boiler; this represents 3750 foot lbs. work in the stroke. There is also the atmospheric pressure on the top of the annular part of the large piston,—150 sq. ins. × 15 lbs. × 1 foot = 2250 foot lbs., making the total prejudicial resistances 6000 foot lbs. in the up stroke, leaving for effective work 9000—6000 = 3000 foot lbs., exactly the same as in the down stroke. Thus in one revolution of the engine 6000 foot lbs. of work would be done. As soon as the steam in the large cylinder has expanded down to 15 lbs. per square inch, a self-acting valve in the exhaust passage which has hitherto been kept closed by the pressure of steam against it, falls open of its own weight, or by pressure of a light spring; so the steam escapes from under the large piston, and another down stroke is made, at the end of which the closing of the exhaust valve is produced by the pressure of the steam admitted to the large cylinder, or by a tappet. At the end of the up stroke the steam is not all discharged from the large cylinder, as the trunk will remain full at atmospheric pressure; so the steam actually used for each double stroke of the engine will be only four-fifths of a trunk full, or 0·28 cubic feet. If we suppose the engine to be running at 35 revolutions per minute, 588 cubic feet of steam per hour will be used, or 92 cubic feet per horse power per hour, (the power, in the instance cited, being 6·39 horses.) This, at 75 lbs. absolute pressure per square inch, is generated from 15 lbs. of water per hour, with a consumption of 21 lbs. of coal—hence the consumption of fuel will be but 2 lbs. of coal per indicated horse power per hour, corresponding to a duty of 110,000,000 foot lbs. per 112 lbs. of coals consumed. Comparing this with the Cornish engines, we find the results favorable to the differential engine; for of the 34 engines reported in Cornwall for September, 1864, the average duty was but 49,800,000 foot lbs., and even the highest duty was only 70,800,000 foot lbs.; and the greatest economy yet attained by any Cornish engine over long periods of working was not more than 109,000,000 foot lbs. per 112 lbs. of Newcastle coal consumed.

It may be further remarked that in the manufacture of the differential engine comparatively little labor would be required, as there is scarcely any fitting about it, and there is but one valve (that being self-acting), and no glands nor eccentrics.

The Surface Condenser Superseded. *

From the London Mechanics' Magazine, February, 1865.

A fulfilment of the title of this work would mean little less than a revolution in marine engineering. The important function intended to be carried out by the surface condenser—that of saving the fuel now lost in blowing off and in the formation of incrustations on the heating surfaces—can scarcely be said to be achieved without many counterbalancing drawbacks. It was thus with some amount of *empressement* that we have opened the work before us with a view to see how it answered to its title. We may as well at once say that the matter inside very well bears out the promise on its title-page. M. Emile Martin certainly explains himself with remarkable clearness and precision, and he is also generally very careful to back up his assertions with facts and proofs which leave as little doubt as possible in the minds of his readers.

To give a brief idea of the substitute for the surface condenser, we may say that M. Emile Martin uses superheated steam in order to raise the temperature of the feed water. This is with the object of separating the salts held in solution, which would otherwise form incrustations in the boiler. Exhaust and saturated steam have been long used with more or less success on the continent for the same purposes, but the efficiency of these plans has been lessened from their comparatively limited heating powers. M. E. Martin has thus had the very simple and yet extremely happy idea of previously superheating the steam he uses as the agency for precipitating the salts contained in sea and other waters. In thus increasing the efficiency of a previously known form of feed water heater, he raises it to the level of the importance of the expensive surface condenser. Instead of directly introducing the feed water into the boiler, it is injected in the form of a fine shower, through a rose, into a casing filled with saturated steam. This steam is fed from the boiler itself. The water, by its contact with the steam, rapidly acquires a high temperature, which is additionally raised by means of a current of superheated steam entering the apparatus in a contrary direction to the water. This water is at last changed into steam, leaving all its incrustations on perforated plates contained in the vessel. The steam generated in the vessel then flows into the steam room of the boiler, while the water, which is considerably heated, is conducted by means of a pipe into the bottom of the boiler. Steam can be taken from any source as long as it possesses, at its entry into the vessel, a pressure at least equal to that in the boiler which has to be fed. Nevertheless, in order to obtain the utmost amount of economy, it is indispensable that the steam which is to be superheated be drawn from the boiler itself. The invention will be found illustrated and described at page 174 of our last volume in the number for September 9th, 1864.

The efficiency of this arrangement is very evident, because, in a small and compact apparatus, it is possible to raise the water to such a temperature that it can deposit all its incrustation. In fact, the

* "Le Substituant du Condenser á Surface, nouvelle Application de la Vaper Surchauffee," par Emile Martin. Londres; Barthes and Lowell, 1865.

steam fed from the boiler and superheated at the expense of heat which might otherwise be lost, becomes a powerful agent, giving out all its caloric in the purifying vessel. The same results could not be obtained either from exhaust or even saturated steam. Many facts cited in his work corroborate the assertions of the author, and as far as regards the purification of the water, we cannot but think very highly of the invention.

But then comes the question: Is M. Emile Martin's apparatus really a substitute for the surface condenser? There can be no doubt that it is a substitute for it in so far, and in so far only, as the surface condenser is a water purifier. Of course, Mons. Martin could never intend to supersede, by means of a water purifier, the ordinary condenser and air-pump. He merely takes the ordinary Watt's condenser and adds to it an apparatus that allows it to perform the functions of the new-fangled and cumbersome surface condenser. But also, in addition to this, the hot water from the apparatus is conveyed and passed into the boiler. As is remarked by Mr. Thomas Halliday, M. Emile Martin's apparatus, if well applied, will, with an ordinary condenser, allow an engine to effect as much economy as if furnished with a surface condenser. An ordinary marine engine generally gives out one indicated horse-power by the consumption of from 3½ to 4 pounds of good Welsh coal per hour. An engine furnished with surface condensers affords an indicated horse-power by the consumption of 2½ to 2¾ pounds of coal per hour. Mr. Halliday thus fairly estimates the loss of heat through blowing off at 33 per cent.; all of which can be saved by means of an efficient apparatus for initially getting rid of the salts that require blowing off and that led to incrustation. *En resumé*, this apparatus seems, from the great practical advantages it offers, of very great importance, and we hope to return to the principles that it involves.

In the second part of M. Emile Martin's work, we find some really interesting details on the applications of his improved steam generating apparatus. The leading idea of this invention consists in using two fire-places, and, therefore, double firing. From the upper part of each, tubular flues rise up to a hollow chamber within the boiler. From this chamber descend one or more flues, at whose lower portion is a perforated grating of fire-clay, on which there is constantly kept a quantity of incandescent fuel. Below this is a space communicating with a chimney, into which the products of combustion are exhausted by means of a fan or by any other plan for producing a draught. In order to try the plan, the Great Eastern Railway Company has already applied it to an old locomotive now working as a stationary engine at the Stratford station. This old boiler, furnished with M. Emile Martin's apparatus, is able to provide with steam an engine of one hundred horse-power, and with an economy of 33 to 40 per cent. over the fifty-horse boilers built up close by. These boilers are still in a very good state, and the advantage over them obtained by the old locomotive boiler furnished with this apparatus, seems mainly due to the consumption of smoke obtained by the latter. In this work is also contained a report from two engineers addressed to Mr. Sinclair, the

locomotive superintendent of the Great Eastern Railway, showing that by means of this arrangement, 10 pounds of water were evaporated by the use of only one pound of fuel, exclusive of the fuel used for getting up steam. At page 152 it is observed that Messrs. Kitson and Co., of Leeds, are now constructing a new locomotive on this plan, ordered by the Great Eastern Railway Company, who, as we just stated, have already carefully tried the apparatus. When this locomotive is once on the line, we may be able to allude to its practical performances.

On the Supposed Nature of Air prior to the Discovery of Oxygen.

By GEORGE F. RODWELL, F.C.S.

From the London Chemical News, No. 255.

(Continued from page 200.)

8. *Early Chemistry of the Air.*—From the title of these papers it would naturally be supposed that their object was to give a chemical history of the air, and such was the original intention; but from the fact that many of the experiments of the earlier philosophers are partly physical and partly chemical, and from other causes, I found it impossible to speak of the chemistry of the air alone. I have, therefore, thought it better to give what Mr. Boyle would have called a *physico-chemical* history of the air.

Pneumatics rose to the rank of a science long before chemistry; hence the physical properties of the air were studied before its chemical properties, and hence it follows that the preceding papers have treated of the former rather than of the latter. We have now to consider the early chemistry of the air.

The theory of the mutual convertibility of the four ancient elements was admitted from very early times; it was a tenet in the philosophy of Anaximenes of Miletus, in that of the Stoics, and in that of Aristotle; and it obtained almost universally, either as a whole or in part, till comparatively recent times; we find it admitted in all works on alchemy and chemistry, and in almost all physical treatises published before the 17th century.

As part and parcel of this theory it was believed that water was converted into air by the action of heat, and that air, when submitted to condensation and intense cold, became water.

Among the very few who denied this was Van Helmont,* who maintained that if air could be converted into water by condensation and cold it would assuredly become water in very cold weather when condensed in an air-gun; he adds, moreover, that water never becomes air, because if we distil a known weight of water in an alembic we find the same weight in the receiver at the end of the operation, the water being "retorted or struck back"† into its own form again.

* Born, 1577. Died, 1644.

† *Alembic* is evidently a word of Arabic origin. Chemistry took its rise in Arabia, and the alembic was probably one of the earliest invented chemical vessels: the word *alembicus* frequently occurs in the latin translation of the works of Geber, the first writer on chemistry. The *retort* is a modification of the alembic, and received its name from *retorqueo*, because the liquid which undergoes distillation is *turned back* from the gaseous condition into its original liquid form.

Van Helmont was well aware of the evaporation of water at the ordinary temperature, and it was to distinguish this vapor from steam that he introduced the word *gas* into chemistry. "But because," he writes,* "the water which is brought into a vapor by cold is of another condition than a vapor raised by heat; therefore, by the license of a paradox, for want of a name, I have called that vapor *Gas*, being not far severed from the *chaos* of auntients. In the meantime it is sufficient for me to know that gas is a far more subtile or fine thing than a vapor, mist, or distilled oylinesse, although, as yet, it may be many times thicker than air. But gas itself, materially taken, is water as yet masked with the ferment of composed bodies."

I have invariably seen *gas* derived from the German *geist:* the derivation from *geist* is more plausible than that from *chaos:* nevertheless, the latter, although obscure, is not, I conceive, unintelligible.†

Hesiod, who is supposed to have lived about 900 B. C., is said to have been the first to introduce the idea of the χαος, but it is probable that he borrowed it from Sanchoniatho,‡ the most ancient heathen writer.

The "chaos of the ancients" was conceived to be a confused mixture of elements, from which, when order and harmony were restored by the Creator, the universe was produced. Now, Van Helmont conceived that water is the primal element, from which everything but air and fire is evolved; all substances, animal, vegetable, and mineral, are produced from it and return to it; hence the vapor of water would be a confused mixture of the elements, or, at all events, a something from which all material substance could be produced, and inasmuch as this had hitherto received no name, he determined, from its resemblance to the ancient chaos, to call it *chaos*, which, by an easy change, becomes monosyllabic (chas), and then has almost the sound of *gas*.

From an early age, cupping glasses were caused to draw blood from a patient by placing fire within them to rarefy the air; according to

* "Oriatrike, or Physick Refined." Written by that most Learned, Famous, Profound and Acute Philosopher and Chemical Physitian, John Baptista Van Helmont, Toparch or Governor in Morede, Royenborch, Oorschot, Pellines, &c. Rendered into English by J. C. (John Chandler), sometime of M. H. Oxon. London, 1662.

† In order that it may be seen that Mr. Chandler's translation has nothing to do with the obscurity of the sentence, I have given the original below from "Johannis Baptistæ Van Helmont Opera Omnia Francofurti," 1707, p. 69. "Progymnasma Meteori," par. 29, in which the sentence stands as follows:—"Verum quia aqua in vaporem, per frigus delata, alterius sortis quam vapor per calorem suscitatus. Ideo paradoxi licentia in nominis egestate halitum illum *gas* vocavi non longè à chao veterum secretum. Sat mihi interim, sciri quod gas vapore, fuligine et stillatis oleo-sitatibus, longe sit subtilius, quamquam multoties aere adhuc densius. Materialiter vero ipsum gas aquam esse fermento concretorum larvatam adhuc." The author of the article on Van Helmont in the "Nouvelle Biographie Générale" writes as follows:—"Lenom de *gaz* ou *gas* (orthographe de Van Helmont) est derivé par corruption de *gahst* (*gaist*) qui signifie *esprit*. Suivant d'autres il derivé de *chaos*, de *blas* (souffle), on de *gaescht* (écume)."

‡ For the account of the Phœnician cosmogony given by Sanchoniatho, see "Ancient Fragments of the Phœnician, Chaldæn, Egyptian, Tyrian, Indian, Persian, and other writers," &c., by J. P. Cory.

Hero, of Alexandria, the fire "*consumes and rarefies*" the air within them, just in the same way that fire consumes and rarefies water and converts it into air. In the time of Francis Bacon, the experiment of burning a candle in a bell jar inverted over water was well known. Bacon denies that air is consumed by the flame, as some imagined; he explains the rise of water into the jar by supposing that as soon as the flame has been "suffocated by the close air," the water rises to occupy the space previously occupied by the flame, in order to prevent the formation of a vacuum. Van Helmont also denied that air is consumed by fire; this arose from the fact of his failing to distinguish between a body capable of supporting combustion, and a combustible body. If air, he argues, is consumed by fire, the whole air would have been inflamed long ago by one single candle, and would have perished. Moreover, if air could be burnt it would become changed, and would cease to be an element, whereas we know it to be a body not compounded of parts, but simple and unalterable.

The calcination of metals was one of the principal operations practised by the alchemists and early chemists; in all their writings we find a prominent place given to a description of this process.

Massicot and minium (PbO and Pb_3O_4) were much used by the ancients. Klaproth found 10 per cent. of oxide of lead in a specimen of red glass from an Egyptian mummy case; and Davy, on analyzing the dark yellow coloring matter of a piece of stucco found in an ancient Roman ruin, proved it to consist of a mixture of minium and protoxide of lead.

Geber, who wrote in the eighth century, was the first to notice that the calx of lead possessed a different weight from that of the lead which produced it. He writes as follows:—* "Et licet non multum perfectioni approximet, ex eo tamen per nostrum artificium defacili argentum formamus, *et non servat pondus proprium in transmutatione, sed mutatur in novum pondus.* Et hoc totum in magisterio acquirit. Est etiam plumbum argenti examen in cinericio, cujus causas dicemus."

Cardanus† added to this fact by stating, that the gain of weight amounted to *one-thirteenth*‡ the weight of the lead taken. . . . "Nam plumbum," he writes,§ "cum in cerusam vertitur, ac uritur, *tertia decima parte sui ponderis augetur.*"

The explanation which Cardanus gives of the cause of the increase of weight is perfectly unintelligible to us, but during the 16th century many theories quite as impossible were brought forward to account for physical phenomena. The lead, he says, during calcination "dies;" the celestial heat which gave it life, and rendered it light, is dissi-

* "Gebiri Philosophi ac Alchemistæ Maximi de Alchemia." 1531. Cap. 35. "Sermo in Saturno." Translated into Latin from the original Arabic.

† Born, 1501. Died, 1576.

‡ 100 parts of lead require 7·173 of oxygen for transformotion into PbO; and 9·343 of oxygen for transformation into Pb_3O_4.

§ "Hieronymi Cardani Medici Medeiolanensis. De Subtilitate." Libri xxi. Parisiis, 1551. Book v. De Mixtione et mixtis imperfectus, sen metallicis."

pated, and it consequently becomes heavier, just as animals after death become heavier than before, because their celestial heat has vanished.

Cæsulpinus* states that lead gains from 8 to 10 per cent. during calcination. "Peculiare huic," he writes,† "quod derelictum fertilius reviviscit, crescit enim imbribus; unde chemistæ argumentum sumunt, etiam, aurum, et argentum augeri posse. Sed illud magis admiratione dignum est, *quod ustum in fornace donec cinis fiat, crescit ejus pondus octo aut decem pro singulis centenariis*, ut metallici testantur."

Cæsulpinus attributed the increase of weight to the presence of soot, which he conceived struck against the dome of the furnace in which the calcination was effected, and, being beaten back, fell into the crucible.

9. *John Rey.*—About the year 1628 a M. Le Brun, of Bergerac, calcined 2 lbs. 6 ozs. of tin, and found, on weighing "to ascertain the loss," that the calx weighed 2 lbs. 13 ozs. He next repeated the experiment with the same weight of lead, and found a loss of 6 ozs.‡ Le Brun mentioned the experiment to several of his friends, but not one of them could give an explanation of the cause of the effects observed, and ultimately he applied to John Rey,§ an ingenious physician of his acquaintance residing at Bugue, in Perigord.

The subject was investigated by Rey, and the results of his inquiry were published in 1630 at Bazas, a small town in Provence.‖

Rey's first object was to prove that the air has weight: taking it

* Born, 1519. Died, 1603.

†"De metallicis, libri tres: Andrea Cæsulpino auctore." Ad sanciissimum dominum nostrum, Clementum viii. Pont. Max. Romæ. Ex. typographia Aloysii Zannetti 1596. Lib. 3, cap. 7.

‡ This loss was due to an error of manipulation, arising either from the heat of the furnace being too intense, and too long continued, or from the action of the fused oxide on the crucible.

§ Born at Bugue in the later part of the 16th century. Died, 1645.

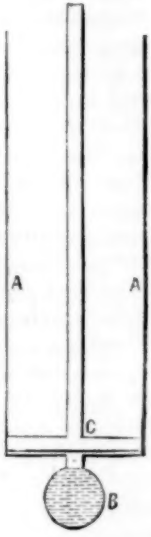
‖ Rey's work is entitled "Essays de Jean Rey," Docteur en Medecine: Sur la recherche de la cause pour laquelle l'estain et la plomb augmentent depoids quandon les calcine." The dedication is to the Duc de Bouillon, and is signed "Rey, au Bugue lieu de ma Naissance dans votre Baronnie de Lymail; le premier jour de Janvier, 1630." The treatise is in the form of twenty-eight short essays, extending over 144 small pages. It is *extremely rare*. A reprint was published in Paris, by M. Gobet in 1777, and a translation by Mr. Children appeared in the 21st, 22d, and 23d volumes of the *Quarterly Journal of the Royal Institution* for 1821 and 1822. I have consulted the original 1630 edition (of which there is an excellent and complete copy in the British Museum Library), and Mr. Children's translation.

The following curious lines by a M. Bereau, are printed at the commencement of the essays:—

"Icyde plus en delaissant,
Des siecles passez la creance,
Vous trouverez l'air se pesant
Qu'on l'examine a la balance.
Vous verrez que cot element,
Se pese en soy par accident,
Vous verrez comme il se r'affine;
Et par un miracle nouveau
Peu s'enfaut qu'il ne se calcine
Par l'effort d'un rouge fourneau."

for granted that bodies cannot descend unless they possess weight, we must admit, he says, that air possesses it, because if we pull a stake out of the ground, air at once rushes in and fills the hole which is left; and however deep we may dig a well, air will descend into it and completely fill it. He mentions, moreover, that if air is compressed in a balloon, the latter, on weighing, will be found to be heavier than before.

When certain liquids of different density are mixed together they are afterwards found to separate into distinct layers; so, argues Rey, if a long tube were filled with wine the upper layer would be more spirituous than the lower, and hence he infers that the air on the top of a mountain is less dense than that at its base.



Rey believed that water, by the action of heat, is converted into air, and he describes a method of determining the volume of air produced from a known volume of water. A hollow cylinder of metal, AA, open at one end, has an orifice made in the closed end, into which the beak of a small elopile, B, can be fitted air-tight. A piston, C, moves freely in the cylinder. The piston is forced down to the bottom of the cylinder, and the elopile, filled with water, is then securely fitted into its place. Heat is applied to the elopile until the water it contains is completely converted into vapor, and the height to which the piston is raised is noted. By comparing the capacity of the elopile with that of the cylinder below the piston, the relation of the space occupied by the water to that of the space occupied by the vapor produced from it can obviously be readily determined.

The eleventh of Rey's essays is entitled "L'air est rendu pesant par le separation de ses parties moins pesantes." Just as in distilling wine, a distillate more subtle than wine passes over, and a residue more dense than wine is left in the retort, so, argues Rey, air may be distilled, a "thickened air" being left as residue. We know that air is thickened by the heat of the sun, because soon after sunrise a trembling* of the air is sometimes observed. Now, the air near a furnace also trembles, and is therefore thickened. "For the violence of the fire, subtilizing all the air that comes near it, will drive an immense quantity of it to a distance, leaving around itself of this immense quantity only a kind of dregs, which, from its glutinous weight, cannot fly off."

* Rey undoubtedly here alludes to the unsteady appearance which objects possess when seen through air having a different density from that around it, an effect due to the alteration of the refractive index of the heated air. It sometimes happens after a very hot day that there are layers of the air possessing different densities, the layer in contact with the soil being heated, and then ascending to make way for colder air. Astronomers are frequently unable to work on account of the unsteady appearance of the objects they view, an effect due to the same cause.

The sixteenth essay is entitled, "Response formelle à le demande pourquoy l'estain, et le plomb augmentent de poids quand on les calcine." "To this question, then," he writes, "resting on the foundations I have laid, I answer *et soustiens glorieusement*. That this increase of weight comes from the air, thickened, and made heavy, and in some degree rendered adhesive in the vessel by the violent and long continued heat of the furnace, which air mixes with the calx (its union being assisted by the continual stirring), and attaches itself to its smallest particles; no otherwise than as water when sand is thrown into it makes it heavier by moistening it and adhering to its smallest grains."

In the eight following essays Rey refutes the opinions of Cardanus and Cæsulpinus, and of several friends of Le Brun, who attributed the increase of weight to the absorption of "the vapors of charcoal," of "the volatile salt of charcoal," of "the volatile mercurial salt," of "moisture attracted by the calx," and of matter removed from the calcining vessel.

In the twenty-fifth essay Rey mentions a single experiment which refutes the opinions of all his adversaries. It will be observed that the above objections are founded on the mode of heating the metal to be calcined. Rey now proves that heat and air alone produce the change.

Hamerus Poppius* mentions an experiment in which he calcined antimony by converging the rays of the sun upon it by a lens. So soon, he writes, as the cone of rays is directed on the antimony, "cum multi fumi profusione calcinabitur . . . et (quod mirabile) licet copiosus fumus multum de antimonio dissipari arguat, tamen antimonii pondus post calcinationem auctum potius quam diminutum deprehenditur." Now, in this instance Rey argues, it is impossible that "the vapors of charcoal," or any of the other volatile bodies supposed to be produced during the calcination in a furnace could have attached themselves to the calx, and yet it was found to weigh more than the antimony which produced it.

Rey next answers the question why a calx does not increase in weight *ad infinitum*. Following up the analogy of sand moistened with water, he replies, may mix sand with sand and water with water in any quantity you please, but this cannot be done with sand and water, for if you add water to sand until it is thoroughly wetted, the sand will take up no more water; it is thus with the calx,—the thickened air attaches itself to its most minute parts, "mais quand tout en assublé, elle n'en sçauroit prendre davantage."

Certain bodies, such as lead and tin, have but little volatile matter, and consequently leave a large quantity of ash to attract the thick-

* I am unacquainted with this author, neither can I find his name mentioned in the "Biographie Universelle," the "Nouvelle Biographie Générale," Watt's "Bibliotheca Britannica," nor in the catalogue of the British Museum Library. The quotation given in the text is from a work entitled "Basilica Antimonii Comprobata et Conscripta ab Hamero Poppio Thallino Philochymico," cap. iii. "De calcinatione Antimonii per Radios Solares." This work is printed in the "Praxis Chymiatrica" of Jean Hartmann, published in 1625.

ened air; while other bodies, such as vegetable and animal substances, have a great deal of volatile matter, and consequently leave but a small quantity of ash to attract the thickened air. In the first instance, the air attracted by the calx weighs more than the matter expelled by heat; in the second instance, the air attracted by the calx weighs less than the matter expelled by heat; hence the former class of substances gain weight during calcination, and the latter lose weight. Such was Rey's explanation of the fact that all bodies do not gain weight during calcination.

Rey, by careful observation, became convinced that the weight gained by metals during calcination came from the air alone. It was then necessary to construct a theory to show by what means air could produce such an effect. The train of reasoning which induced him to propound the theory given above may be stated in a few words as follows: Air has weight; air most nearly approaches the nature of a liquid, and may therefore be supposed to act like one; liquids may, by the action of heat, be caused to separate into a heavier and a lighter part; therefore air may, by the action of heat, be caused to separate into a heavier and a lighter part; the heavier part approaches more nearly to the nature of a liquid than air; it is the "dregs" of air, and it has changed its fluidity for a "viscid grossness;" this matter attaches itself to the ashes of bodies during calcination as water attaches itself to sand, and renders such of them as possess much ash heavier than they were before calcination.

Rey did not believe that "thickened air" (*l'air espessi*) is the *cause* of calcination. He held to the old theory that calcination is the expulsion by heat of the volatile matter of the body calcined, the calx being the residual ash;—the ash of an organic body was to his mind as much a calx as the oxide of a metal.

The great merit of Rey was, that he regarded air in the light of a ponderable liquid; that which holds good for a liquid, he assumed, holds equally good for air. He thus became able to grapple with an intangible body, and to reason on that which had hitherto from its subtlety eluded the grasp of the philosophers of all previous ages.

Rey's theory was, indeed, fallacious; still, it was a great step in advance of all that had been done in former ages; there is impressed upon it a stamp of a great and energetic intellect. We must not judge of it by what has been done since; we must think of what was done before; we must think of it as the work of a man removed from a great centre of learning; from the converse of scientific men; from every external source of knowledge; compelled to work alone, to think alone. Let it be remembered, moreover, that experimental science had not yet left its cradle; middle age superstition was still very rife; philosophy founded on reasoning had not given way to philosophy founded on experiment; the syllogism had not yielded its place to induction; the Church was still dominant—still condemned all that was contrary to the philosophy of Aristotle, and thus cramped and curbed the human intellect; the "Novum Organum" had but just appeared; and the "Dialoghi" of Galileo were as yet unknown to the world.

Rey lived at the commencement of an epoch, and he was the founder of a branch of scientific inquiry which helped to render that epoch glorious. By energy and perseverence he ascended a lofty eminence, whence he saw in the distance an unknown country—dimly, indeed, and far from him; still it was there, and he pointed out its direction to his fellow-men; but explorers were rare in that day, and men cared not to venture across pathless wastes, to ascend hitherto untrod mountains, in order to arrive at that which, when found, might prove a barren and unproductive country.

Rey's work was but little known during the 147 years which intervened between its publication and its reprint in 1777. It was published in a small and obscure town of Provence, and from the fact that at the time of the reprint it was extremely scarce, it is to be supposed that only a few copies were originally printed. Had it been better known, the theory of Phlogiston would never have been propounded, and pneumatic chemistry would assuredly sooner have attained the rank of a science. But soon after the "Essays" were published, the discovery of the pressure of the air diverted the minds of the scientific from the study of the chemistry of the air.

The claims of Rey have never been sufficiently acknowledged. Let all honor be given to him; science ought to venerate such a man—a true philosopher, working for her, and loving her for herself alone. In the history of pneumatic chemistry, the name of Rey deserves to stand side by side with those of Mayow, Hales, Priestly, Scheele, and Lavoisier.

Well did Rey write as the concluding words of his treatise:

"Le travail esté mien, le profit en soit au lecteur, et à Dieu seul la gloire."

To be Continued.

On the Employment of Paraffin for Waterproofing. By JOHN STENHOUSE, LL.D., F.R.S., etc.

From the Practical Mechanics' Journal, April, 1865.

The materials which in modern times were first employed for waterproofing were beeswax and the various kinds of drying oil, especially linseed oil, which were rendered more siccative by boiling or some other of the processes usually employed for that purpose.

About forty years ago caoutchouc was first successfully used, for rendering fabrics and other materials waterproof, by the late Mr. Chas. Macintosh; and after an interval of about twenty years, gutta percha was first imported into this country, and immediately applied for similar purposes.

In 1832 paraffin was discovered by Reichenbach in the course of his admirable researches on wood and coal tars. He, however, only succeeded in obtaining it in very small quantity, so that for a long time it was only known as a chemical curiosity. It is to Mr. James Young that we are indebted for the production of this material on an industrial scale, by his process which he patented nearly fifteen years ago.

About three years since a patent was taken out by Dr. Stenhouse for employing paraffin as a means of rendering leather waterproof, as well as the various textile and felted fabrics; and in August last an additional patent was granted Dr. Stenhouse for an extension of and improvement on the previous one, which consisted chiefly in combining the paraffin with various proportions of drying oil, it having been found that paraffin alone, especially when applied to fabrics, became to a considerable extent detached from the fibre of the cloth after a short time, owing to its great tendency to crystalize. The presence, however, of even a small quantity of drying oil causes the paraffin to adhere much more firmly to the texture of the cloth, from the oil gradually becoming converted into a tenacious resin by absorption of oxygen.

In the application of paraffin for waterproofing purposes, it is first melted together with the requisite quantity of drying oil and cast into blocks. This composition can then be applied to fabrics by rubbing them over with a block of it, either cold or gently warmed, or the mixture may be melted and laid on with a brush, the complete impregnation being effected by subsequently passing it between hot rollers. When this paraffin mixture has been applied to cloth, such as that employed for blinds or tents, it renders it very repellent to water, although still pervious to air.

Cloth paraffined in this manner forms an excellent basis for such articles as capes, tarpaulins, &c., which require to be rendered quite impervious by subsequently coating them with drying oil, the paraffin in a great measure preventing the well known injurious influence of drying oil on the fibre of the cloth. The paraffin mixture can also be very advantageously applied to the various kinds of leather. One of the most convenient ways of effecting this is to coat the skins or manufactured articles, such as boots, shoes, harness, pump-buckets, &c., with the melted composition, and then to gently heat the articles until it is entirely absorbed. When leather is impregnated with the mixture, it is not only rendered perfectly waterproof, but also stronger and more durable. The beneficial effects of this process are peculiarly observable in the case of boots and shoes, which it renders very firm without destroying their elasticity. It therefore not only makes them exceedingly durable, but possesses an advantage over ordinary dubbing in not interfering with the polish of these articles, which, on the whole, it rather improves.

The superiority of paraffin over most other materials for some kinds of waterproofing consists in its comparative cheapness, in being easily applied, and in not materially altering the color of fabrics, which, in the case of light shades and white cloth, is of very considerable importance.

It will be evident from the statements which have just been made, that the employment of paraffin for waterproofing purposes is likely to become very extensive.

Gunpowder Extraordinary.

From the London Mechanics' Magazine, March, 1865.

Captain Schultze, of the Prussian artillery, has just patented, both in England and in most continental countries, a new kind of gunpowder, which possesses some very valuable advantages, and seems to us destined to play an important part in the world. As regards its absolute composition, and also its mode of manufacture, it bears more resemblance to gun-cotton than to ordinary gunpowder; but its form is that of gunpowder, and it has none of those specially dangerous properties which have hitherto prevented gun-cotton from coming at all extensively into practical use. Cotton fibre, it might be well to explain, consists of a substance which chemists call "cellulose," and which is a compound of six atoms of carbon, five atoms of oxygen, and ten atoms of hydrogen; while gunpowder is, chemically speaking, "tri-nitro-cellulose," or cellulose which has had three atoms of its hydrogen taken away and replaced by hyponitric acid. Further, all kinds of wood consist chiefly of cellulose; the cellulose of wood, however, unlike that of cotton fibre, which is quite pure, being always combined with more or less of coloring matter, resin, and various earthy and other substances. This being the case, it is obvious that if we could remove from wood all the substances other than cellulose which enter into its composition, and were to subject the pure cellulose which would then remain to the same chemical treatment that cotton fibre has to undergo in order to its conversion in gun-cotton, we should obtain a substance of absolutely the same composition as gun-cotton, and differing from gun-cotton only in form. This is just what Captain Schultze does, with the result, among others as important, that he gets his "tri-nitro-cellulose," not in delicate filaments, like those of gun-cotton,—a mass of which, of whatever size, on the application of a spark to any part of it, will flash into combustion almost instantaneously, exploding, indeed, with such exceeding rapidity that a charge of it ignited in the powder-chamber of a gun, against a ball pressed tightly home to it, would burst the gun instead of propelling the ball,—but in hard, compact grains of any desired dimensions, and at least as slow of combustion as the densest gunpowder of the same size of grain. While gun-cotton,—being, at least for gunnery purposes, only three times as powerful as its weight of gunpowder,—costs, weight for weight, six times as much as gunpowder costs, and can only be used safely by means of special methods, Captain Schultze's granular tri-nitro-cellulose, while being nearly four times as powerful as gunpowder, costs, weight for weight, considerably less than gunpowder, and can be used in precisely the same way as gunpowder, its substitution for gunpowder requiring no new method or precaution beyond that of using of the new powder only one-fourth as much as of the old. The new explosive agent has thus great advantages, alike over the old "villainous compound" of charcoal, sulpher, and saltpetre, which Martin Schwartz invented five hundred years ago, and which has influenced human affairs perhaps as much as the printing press or the mariner's compass, and over the singular sub-

stance the discovery of which by Schönbein, in 1846, if it has done nothing at all towards bringing about that entire disuse of gunpowder which its distinguished discoverer predicted that it must occasion within ten years, has at least enabled the art of photography to reach a pitch of perfection, which, but for gun-cotton, or rather the solution of it in ether, which is known as collodion, would have been impossible. To this it must be added that Captain Schultze's powder does not foul the guns in which it is used; that the products of its combustion are perfectly transparent gases, offensive neither to the eyes nor to the lungs, and lighter than the atmospheric air, so that they soon pass away; and that its manufacture is much safer than that either of gunpowder or of gun-cotton.

The first process in the manufacture of the new powder is to cut some wood—we are told that any kind will do, but that the harder it is the stronger the powder will be—into sheets or veneers, of a thickness equal to the diameter which it is desired that the grains of the powder to be produced shall have. For powder to be used for ordinary small arms, Captain Schultze recommends that the sheets be about one-sixteenth of an inch thick. These sheets, whatever their thickness, are cut up by a punching apparatus into little cylinders, of diameter slightly less than the thickness of the sheets from which they are cut. The cylinders thus obtained constitute, eventually, the grains of the new powder, which is thus granulated at the beginning, instead of, like the ordinary gunpowder, at the end of its process of manufacture. In order to remove from these cylinders, or grains, all their constituents other than cellulose, they are boiled for about eight hours, in a copper kettle, in a strong solution of carbonate of soda, the solution being changed as often as it becomes discolored; they are then kept in a stream of running water for twenty-four hours, and are next steeped for about two or three hours, being constantly stirred all the time, in a solution either of chloride of lime or of chlorine gas. They are then well washed, first in cold water and afterwards in hot; and are finally kept for a second time twenty-four hours in pure cold running water. They are then submitted for six hours to the action of a mixture of forty parts by weight of concentrated nitric acid with a hundred parts by weight of concentrated sulphuric acid, one part by weight of the grains being placed with seventeen parts by weight of the mixed acids in an iron vessel, which should either be placed in a powerful refrigerating mixture, or have cold water constantly circulating around it. At the end of six hours the grains are taken out, and carefully drained from all adhering acid. They are then kept in cool fresh running water for two or three days, then boiled in a weak solution of carbonate of soda, then exposed to running water again for twenty-four hours, and then dried as completely as possible. Captain Schultze states—somewhat to our surprise—that up to this point the grains are not explosive, and that this drying operation therefore involves no danger. When fully dried, the grains are ready for the last operation but one, which consists in steeping them for ten minutes in a solution of some salt or salts containing

oxygen and nitrogen. Captain Schultze prefers nitrate of potash (saltpetre) or nitrate of barytes, or, what he finds is better still, a mixture of both. He recommends for every hundred parts by weight of the grains, two hundred and twenty parts of water, having dissolved in it twenty-seven and a half parts of nitrate of potash and seven and a half parts of nitrate of barytes. The temperature of the solution should be 112° Fahr. After having been stirred about in this solution for ten minutes, the grains have only to be taken out and drained, and then dried. The drying must be done, this time, in a chamber kept at a temperature of from 90° to 112° Fahr., and will occupy about eighteen hours.

We have spoken again of gun-cotton as being, for gunnery purposes, only three times as powerful as gunpowder. Intrinsically, it is six times as powerful as gunpowder, and in applications to mining and engineering purposes, and also as a charge for shells, it has practically six times the value of its weight of gunpowder. No method is known, however, by which the *whole* of the force generated by its combustion can be utilized for the propulsion of projectiles from guns. For gun-cotton to exert the utmost energy of which it is capable, it must be compressed as much as possible, and exploded in the most confined space into which it can be got; but if a charge of gun-cotton be rammed down in a gun, after the manner of an ordinary powder charge, its explosion, as already stated, will burst the gun before the ball has had time to begin to move. Not only, therefore, must gun-cotton intended for use in guns not be compressed at all, but it must be allowed more space in the gun than it is capable of filling, even without compression. "It is a discovery of General Lenk," said Mr. Scott Russell, in the paper on gun-cotton which he read before the Royal Institution some months ago, and which we reported at the time, "that to enable gun-cotton to perform its work in artillery practice, the one thing to be done is to *give it room*. Don't press it together; don't cram it into small bulk! Give it at least as much room as gunpowder in the gun, even though there be only one-third of the quantity (measured by weight). . . . . The ramming down which is essential to the effective action of gunpowder is fatal to that of gun-cotton. To get useful work out of a gun-cotton rifle, the shot must on no account be rammed down. Air left in a gunpowder barrel is often supposed to burst the gun; in a gun-cotton barrel it only mitigates the effect of the charge. The charge for a gun-cotton rifle must be enclosed in a hard, strong pasteboard cartridge, to keep the cotton from compression and give it room to do its work. . . . . For artillery, a hollow space must be preserved in the centre of the cartridge, by some means or other. The best means is to use a hollow thin wooden tube to form a core. This tube should be as long as to leave a sufficient space behind the shot for the gun-cotton. On this long core, gun-cotton yarn is wound round, like thread on a bobbin." These expedients certainly prevent the gun-cotton from bursting the guns, but they also prevent it from exerting upon the shot more than one-half of the energy set free by its combustion.

The discovery by Baron Lenk, who is a Major General in the Aus-

trian service, of this safe method of using it in guns, and also of improvements in its manufacture, rendering it both less liable to spontaneous combustion and in every way safer, both to store and to handle, than when manufactured as formerly, have caused more attention to be given to gun-cotton in this country, both by military and by civil engineers, during the last twelve months, than ever before. Considerable quantities of it have been manufactured lately by Messrs. Thomas Prentice and Co., of Stowmarket; and among miners and civil engineers, for whose special purposes it possesses great advantages over gunpowder, it has been growing rapidly into favor. As an illustration of the value of the advantage which is constituted by its explosion producing no smoke, Mr. Scott Russel in the lecture just quoted from, stated, that if gun-cotton were to be used instead of gunpowder in the completion of the tunnel which is being bored through Mont Cenis, the final completion of that great enterprise would be hastened many months, owing to the workmen being able to return to their tasks almost the instant after an explosion of gun-cotton, whereas after an explosion of gunpowder, under such circumstances as in the Mont Cenis tunnel, the air in the immediate neighborhood is unbreathable for a considerable time. Captain Schultze's powder, however, as we have seen, shares with gun-cotton both this and all the other advantages of that substance, and possesses in addition several important advantages which are exclusively its own.

Improvements in Fire-arms.

Translated for the Journal of the Franklin Institute.

Mr. Seguier presented to the French Academy of Sciences a very interesting memorial upon improvements in fire-arms. The idea which underlies his proposed improvements is that of putting the ball in motion at first gradually and increasing the pressure upon it as it gains velocity, under such conditions that all the force of the explosion may be exhausted before the ball leaves the gun. For this purpose various expedients are suggested: the ignition of the charge first at its front part immediately in contact with the ball; the interposition of an air-space between the charge and the ball, so that the air may act by its elasticity, (neither of these proposals are new;) the forming the charge of two kinds of powder, a slow burning to be first ignited, and a more rapid to act on the ball after its inertia had been overcome. A modification of this latter consists in using gun-cotton in place of the rapidly burning powder. The cartridges made upon this principle by Mr. Chaudeur, are claimed as giving the following advantages:

1st. An economy, by avoiding the loss of powder thrown out of the piece unburnt. This is gained by igniting the front part of the charge.

2d. A reduction of the recoil, by the insertion of an air-chamber between the breech-piece and the charge.

3d. An increase of the range, by the combination of slow and quick burning powders in the same cartridge.—*Cosmos.*

For the Journal of the Franklin Institute.

Coal Trade in Europe.

The extraction of coal in France during 1863, is estimated at 10,000,000 tons; as the importation of foreign coal was 5,344,260 tons, the consumption amounts to 15,344,260 tons, or about 400 kil. (882 lbs.) per head. Belgium produced 10,000,000 tons, but exports 3,500,000 tons. The 6,500,000 tons which it consumes represent 1280 kil. (2822 lbs.) per head, or three times as much as in France. England produced 86,000,000 tons of coal, of which 7,934,000 were exported. The internal consumption is then 78,000,000 tons, which represents 2900 kil. (6394 lbs.) per head, or about seven times as much as in France. One-third of the coal used in France is imported from England Belgium and Prussia.—*Cosmos.*

Preparation of Aluminium.

From the London Artizan, Mar., 1865.

Mr. Corbelli has found a simpler and more economical process for procuring aluminium than that heretofore used. The metal is prepared from clay, first carefully purified from foreign matter, then dried and treated by an acid to remove iron. About six times its weight of sulphuric acid will answer this purpose. The clay is then allowed to settle, dried again, and mixed with about twice its weight of prussiate of potassa, the quantity of which is to be increased or diminished according to the contents of silica in the clay. To this mixture one and a half times the weight of the clay is added of common salt, the mixture placed in a crucible, and heated to a white heat. After cooling, the aluminium will be found at the bottom of the crucible.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, April 20th, 1865.

The members were called to order by the President, Wm. Sellers, in the chair, the number present being 32, as per roll.

The minutes of the last meeting were then read and approved. The minutes of the Board of Directors were reported, as also those of the Standing Committees. The Special Committee on Weights, Measures, and Coinage, reported progress; as also the Committee on Steam Expansion, and the Committee to draft a petition to Councils, regarding the appointment of an inspector of steam boilers, presented the petition, engrossed and ready for transmission.

Donations to the Library were received by the Board of Managers, viz: From the Royal Institution and the Society of Arts, London; the Royal Irish Academy, Dublin, Ireland; Thos. Oldham, Esq., Superintendent of the Geological Survey of India, Calcutta, India; the Smithsonian Institution and Frederick Emmerick, Esq., Washington, D. C.; the Managers of the Lunatic Asylum, Utica, N. Y.; the Amer-

ican Philosophical Society, H. P. M. Birkinbine, Esq., Prof. John F. Frazer, the Directors of the Girard College, and B. F. Palmer, Esq., Philadelphia.

New business being then in order, Prof. F. Rogers, as chairman of the Committee on Meetings, introduced to the members of the Institute, Mr. Albert Leeds, who then read a paper as follows, on

The Geography and Geology of Petroleum.

The northenmost point on the American Continent at which petroleum has been largely found is in Canada West, at Enniskillen, near Lake St. Clair. The accounts of the quantities which have issued from single wells in this locality are too well authenticated to be doubted. In the year 1862, when Pennsylvania produced so much oil that its commercial value became too low to make it profitable to pump wells distant from a market, these Canada wells were allowed to overflow with oil acres of ground. They became choked up by neglect, and it is but recently that they have been reopened and properly worked. Lying nearly on the same parallel are, to the eastward, Lockport, in Niagara county, New York, and Hamilton, in Canada, on the shores of Lake Ontario; to the westward, St. Clair county, Michigan. In all these localities oil has been found.

They constitute, in fact, a boundary line 200 miles in length, which limits the oil regions upon the north. Now, carry this line southward for 350 miles. It will stop near the source of the Kanawha River, upon the slopes of the Alleghany Mountains, in West Virginia. This tract, 200 miles broad, 350 miles long, and embracing 70,000 square miles, is at present the only region east of the Rocky Mountains, where petroleum has been found in workable quantity. Now, if a diagonal be drawn from the northeast to the southwest corner of this tract, it will be seen

1st. That the Alleghany Mountains and the Blue Ridge Mountains are parallel to this diagonal.

2d. That the general course of the Ohio and Alleghany Rivers is likewise parallel to it.

3d. That all the rivers, creeks, brooks, and ravines where petroleum has been found, either in the valley-basins of those great rivers, or in the water-sheds which feed them, flow either parallel or at right angles to this same diagonal.

In concluding this short sketch of the geography of the oil regions, may it not be asked whether the great geographical fact stated above, has not some intimate connexion with the geology of petroleum and the action of oil wells?

Everywhere throughout the world geologists have found that certain rocks which are similar in chemical nature, in physical characters, and in organic remains, are always found in the same relative position to each other. Any series of rocks thus allied, is held to be the result of the same physical forces, and marks a distinct era in the building up of the crust of the globe, called a geological epoch. Such a group of rocks is called a formation. Deepest in the earth, and first in order

in point of time, was built up a great group of rocks, all characterized by the absence of any trace of animal life. These are of unknown thickness. They underlie all other rocks, and man would have never known of their existence except for those mighty convulsions of nature which have rent asunder the earth's surface, and sent up through fissures or protruded from the craters of volcanoes the molten matter of these first foundation masses. Upon them rests a long series of sandstones and limestones of very varying thickness, known as the lower and upper Silurian systems. Another step towards the earth's surface brings us to the Devonian system, wherein we first find petroleum in the United States, and this, together with another great formation, called the carboniferous, include all the rocks from which has so far been obtained in the oil regions above referred to.

But any description of the oil-yielding rocks will be unintelligible, if it be for a moment supposed that the geological formations lie one upon another like the leaves of a closed book. Geology teaches that some mighty force, in ages long past, has operated from below in such a way as to bring up the edges of the lower layers of rock to the earth's surface. They would, therefore, appear to us like the edges of the leaves of a book, when the book was wide opened. And thus it happens that formations but two or three miles in thickness, may be stretched over hundreds of miles of the earth's surface, and that by beginning at some definite point and walking in the proper direction, we can in great detail the rocks which we wish to consider.

Let us take our geological sketch from the same point at which we took a bird's-eye view of the geography of the oil regions. Standing at Enniskillen, let us look far away to the southwest along the line of that diagonal to which I have already called your particular attention. At Enniskillen petroleum is found in the corniferous limestone which occupies the lowest point of the Devonian system. This corniferous limestone is composed in great measure of fragments of corals and sea-shells. The cavities of these corals and sea-shells are often filled with liquid bitumen, and the inhabitants of those places where this corniferous limestone exists, find the bitumen issuing in the form of tar from the kilns in which they reduce this rock to lime. According to an analysis made by Hunt, the chemist of the Canadian Geological Survey, specimens of this corniferous limestone yielded from 7·4 to 12·8 per cent. of bitumen, fusible, and readily soluble in benzole. Its thickness in Enniskillen is about 100 feet. Lying directly above the limestone is the Marcellus shale. Throughout this and the formation next to be described, there are many septaria or modular concretions highly charged with bitumen. This Marcellus shale is about 50 feet thick in that part of Canada lying between Lake Ontario and Lake Huron. And in the cavities and fissures of these two rocks, which in Canada are not above 150 feet in thickness, was stored up thousands of years ago those millions of gallons of petroleum hitherto found in Canada. But Lake Erie intervenes, and we must therefore cross over to Western New York if we wish to inspect the rocks in the same order as that in which we commenced.

The rocks which here yield petroleum are found in what New York geologists call the Hamilton group, which lie above the Marcellus shale and corniferous limestone in the geological scale. The oil springs in the vicinity of Lockport and along the banks of Chautauque and other lakes in western New York, are mainly in this group of rocks. In fact, it was from Seneca Lake that the oil was brought, which the Indians traded away to the early white settlers of Pennsylvania and New York, and it was by the tribe which inhabited that lake—the Senecas—that the use of petroleum as a healing ointment was made known. Petroleum was first sold in this country by druggists, under the name of "Seneca Oil." Western New York is now being diligently prospected and already Chautauque Lake is glowingly depicted in the prospectus of a new oil company. In the black shales which exist in the southwestern part of New York, and which are known as the Genessee slates, no oil has yet been found. But where the same rocks reappear far away to the southwest, at Mecca, Ohio, they are found to yield a large supply of lubricating oil. We will put down the thickness of these rocks at 300 feet.

Proceeding further in the same direction, we find the shales and limestones of the Portage group, yielding oil from those wells on Oil Creek, which have been sunk to the greatest depth. These rocks at Oil Creek are 1700 feet thick. Above this, again, we find a long series of alternate slates and sandstones, the latter being sometimes replaced by limestone. If you take a drawing of the rocks in Venango county, wherever the quarryman has blasted away the hill-side, whether you look 400 feet above, or at the rocks just before your feet; whether you make the drawing of rocks along the Big Sandy, or up Sugar Creek, at Walnut Bend, along Oil Creek, or up Cherry Run, everywhere you will get a picture of thin argillaceous shales alternating with sandstones. If an accurate record of any well sunk in Venango county be consulted, it will reveal the same geological structure. As, for example, the following, which I copy from my note-book of a well upon the Alcorn farm, situated upon the Alleghany River, about three miles above Oil City:

Seventy-five feet of a very soft rock, of the nature of gravel; very soft.

Seventy-five feet of a rock, called by the drillers "soapstone." It is, in reality, an argillaceous shale. It has a somewhat gray color, and is harder than the preceding rock.

Ten feet of sandstone, everywhere known as "the first sand rock."

Seventy-five feet, another series of shales distinctly argillaceous.

Twenty feet, "second sand rock."

Two hundred feet, argillaceous slates. Layers of rock, alternately soft and hard.

Fifteen feet, "third sand rock."

Eighty feet, argillaceous slates, which the man who was boring described as "shelly," meaning that they were in thin layers of alternately hard and soft rocks.

If we sum up this record we have 550 feet of this formation in a vertical line. The man who was drilling this well said at the depth of 730 feet, which was the greatest depth he had attained, he had met the same kind of rocks. These rocks belong to the Chemung group, which lies immediately over the Portage, in the geological scale. We may, accordingly, safely estimate the thickness of the Chemung group in Venango county at 450 feet above the surface, plus 750 below, or at 1200 feet. In this group of rocks, nearly all the oil from Oil Creek, Cherry Run, Patchen's Run, Two-mile Run, Horse Creek, etc., has been found. The Catskill formation does not occur in the oil regions of Pennsylvania.

We have now reached the top of the Devonian system, and find, on adding up the above figures, that the total depth to which it has been developed in the oil regions is 4000 feet. Concerning all these 4000 feet of rocks, there is nothing which becomes more strongly impressed upon an observer of the geological features of northwestern Pennsylvania than the belief that they are sedimentary. That they are, in other words, nothing but the broken and pulverized fragments of other rocks which have been deposited from water; that northwestern Pennsylvania was the basin of an ancient sea, which was filled up by the debris of continents.

Ascending in the geological scale, we now come to the carboniferous system. None of the wells which have been sunk along Oil and French Creeks have ever passed through coal. The lowest member of the coal series caps the highest hills near the mouth of Oil Creek, and is, therefore, some five hundred feet above the top of any well which has been sunk in that region. The bituminous coal which exists here is of the poorest quality, and occurs in seams of only a foot or eighteen inches in thickness. But this coal has been selling there at sixty cents a bushel, and the cost of feeding the engine has been one of the principal items of expense in sinking a well. To the south, however, of Oil City, in Cranberry township, and along the Alleghany River, the coal veins become thicker. One stretching along the top of a hill, about seven miles below Franklin, is five feet in thickness. It is now being worked, and is expected to supply Franklin, Oil City, and the points above with superior coal. But Franklin is about five hundred feet above Pittsburgh, and the general dip of the rocks in a southerly direction is such that in the neighborhood of the latter town the carboniferous rocks come down to the surface.

In the territory around Pittsburgh, along the Kiskiminetas River, at Slippery Rock, throughout Butler county, at Smith's Ferry, etc., oil is found in the lower coal measures. In this locality they are 800 feet thick. If we trace the Kiskiminetas River nearest its source, oil is found in the lower coal measures, which are 1000 feet thick. Along the Muskingum, Kanawha, and other rivers and creeks about Marietta and Parkersburg, in Virginia and Ohio, such as the Horse-Neck, Bull and Goose Creeks, the upper coal measures contain the petroleum. They are here 700 feet thick. We have now the

Corniferous limestone,	50 feet.
Marcellus slate,	100 "
Hamilton group,	1000 "
Genessee slate,	300 "
Portage group,	1700 "
Chemung group,	1200 "
Lower coal measures,	800 "
Middle coal measures,	1000 "
Upper coal measures,	700 "
Total depth of oil yielding rocks,	6850 "

In view of these figures let us see what answer should be given to those who are fearful that petroleum is giving out; that nature has manufactured after a stingy fashion the most beautiful means of illumination which she has yet yielded to man; that the refining of petroleum will soon give place to the distillation of bituminous coal; that derricks and tanks will soon cease to villify the landscape of the beautiful Ohio basin; and that soon, with a terrible crash, oil companies will disappear, and leave nothing but paper behind.

Different wells scattered up and down over 70,000 square miles of land, are now producing oil in profitable quantities. In a large portion of this territory, geology and experience tells us that petroleum exists throughout rocks varying from 50 to 7000 feet in thickness. When petroleum has been exhausted by shallow wells, it may be found in deeper ones, as the famous wells along Oil Creek show us. Here wells were put down at first from two to three hundred feet, and a heavy lubricating oil was obtained, by pumping, in small quantities. Afterwards, in localities which had been abandoned as unprofitable, wells were sunk to five or six hundred feet, and flowed one thousand, two thousand, and even in some cases over three thousand barrels daily. Of 340 wells sunk previous to this date between Humboldt Refinery and Rouseville, all that have reached the proper depth have produced oil, and the remainder, 112 in number, will probably experience equal good fortune. These facts alone would justify the statement that henceforth petroleum deserves to be ranked with coal and iron as a solid mining interest.

Such an opinion, moreover, deserves additional weight from a study of the various tracts in Europe, Asia, and South America, where petroleum is collected; and since no statement of this kind has heretofore been published, it will be interesting and valuable to present in this place a world-wide view of petroleum wells. In so doing we must widen to a corresponding degree our ideas of the nature of petroleum. We must recollect that this mineral substance was known many years before the first oil well was sunk near Titusville, and that, under the general name of petrolum, many rock-oils should be included, differing greatly in their nature from those mobile fluids, which a Philadelphian who is familiar with the products of Oil Creek alone, is wont to regard as petroleum. We should remember that easily fusible, pitchy, bitumens are made up of two ingredients, one of which is a solid body like asphaltum, and the other an oily liquid resembling petroleum, and that wherever such bitumens are found, they are to be regarded as indica-

tions of the profitable presence of petroleum. Having made these preliminary statements, we are enabled to speak in a more general manner of foreign oil-bearing rocks, and are not compelled, as we would otherwise be, to regard the few places where petroleum is stated to exist by travelers, in precise terms to exist, as the only ones where it is really to be found.

Petroleum found in South America.—In South America bitumen has been discovered in large quantities on the northern shores of New Granada, Peru, and Venezuela, on the banks of the river Magdalena, at Payta or Payti in Columbia, at Coxitambo, near Cuenca, in Peru, and in many other places. Few of these bitumens have been analyzed, and we possess, at present, but few facilities for comparing them with European specimens. That of Coxitambo has been investigated, and has been found to be a pure hydrocarbon, consisting of 88·7 per cent. of carbon and 9·7 per cent. of hydrogen. In the Travels and Researches of Alexander Von Humboldt, an account is given of a stream of naphtha at the Punta d'Araya, at Cape Cirial, Venezuela. He says that it issues from mica slate, and remarks, as a singular fact, that petroleum should in this spot issue from a metamorphic rock, while at all others it exudes from secondary rocks. And Boussingualt, who has shown in his work on bitumen, that all the vast collections of mineral pitch which exist in the northern parts of South America, must have a geological position corresponding with bituminous schists found in France, quotes this remark of Humboldt, as the only one which goes to contradict his view of the geological position of the American mineral-pitch.

In McCulloch's *Geographical Gazetteer*, reference is made to a great mountain of asphaltum upon the northeastern shores of the great lake of Maracaybo. It sends up, in warm weather, great streams of phosphoric fire, which guide the Spaniards and Indians in ther transits over the lake. They have consequently given to this strange lamp of nature the name of the Lantern of Maracaybo. Around the border of the lake, a circumference of about two hundred and fifty miles, petroleum springs and bitumen abound.

West Indies.—Throughout many of the Islands of the West Indies, and to the north of Venezuela, petroleum springs are found, accompanied generally by deposits of bitumen and vast accumulations of asphaltum. These Islands have been upheaved from the sea, during a recent geological epoch, by violent volcanic action. This may account for the fact that petroleum does not, in the West Indian localities, issue from sedimentary rocks as it does in Pennsylvania, but from igneous rocks, or those which have been forced up to the surface of the earth by volcanic agencies. In very many places in Cuba, petroleum flows from cracks in serpentine rocks. Such petroleum springs have been found for two hundred years at Guanabacoa near Havana. And the narratives of the buccaneers tell us that they used to frequent the Bay of Havana, and collect sufficient bitumen lying exposed on the shore at low water, to pay the bottoms of their vessels. In the eastern part of Cuba, springs are found between Holquin and Mayari,

and in the other direction in the neighborhood of Santiago de Cuba. Of the bituminous coal, or, as it is called by the natives, *chapapote*, found in Cuba, more than one-half is composed of volatile fatty matters. An analysis made by Mr. T. G. Clemson, of chapapote from the Casualidad mine, which is situated about 18 miles from Havana, gives only 34·97 per cent. of coke and the astonishing amount of 63 per cent. of volatile ingredients. It is, of course, an admirable material for the manufacture of gas.

In the great pitch lake of Trinidad there is a great number of holes and fissures, which have apparently been produced by a rending asunder of the hardened asphaltum by volcanic forces, and a subsequent injection of liquid bitumen. And, in fact, this strange operation of nature's hidden forces may sometimes be seen actually going on in the sea, to the southward of Cape de la Brea. Hidden beneath the waves there seems to be a submarine volcano, which sends up occasionally quantities of petroleum to the surface of the water, attended with a mighty boiling of the deep. And in the same manner, the seas in the vicinity of the Cape de Verde Islands are oftentimes covered with petroleum projected from submarine volcanoes. Many years ago an account was published by Dr. Skey in the English Geological Transactions of a "Petroleum or Burning Spring," found at St. Andrew's parish in the Island of Barbadoes. He states that it issues from calcareous rocks, and it would appear from his calling it *green naphtha*, and from the fact that it is largely employed by the natives as a substitute for fish-oil in lamps, that the petroleum of Barbadoes is nearly analogous to what we are here familiar with under this name. Mr. Herapath analyzed the coal found in Barbadoes, and found that it was equally rich with that mined in Cuba, consisting of 62 per cent. of fatty matters and 37 of coke.

Europe.—In the next place, let us examine the bituminous deposits of Europe. In England, little has been found compared with the extensive developments which have been made in France. Bitumen has been encountered at the Hurlet mines near Paisley, where it encloses crystals of calcareous spar, and at the Odin mines in Derbyshire. It strongly impregnates the peat cut near Ormskirk, Lancashire, and penetrates the limestones of East Lothian in Scotland.

About the year 1840, a mania, M. Dumas tells us, prevailed in France, for putting bitumen to countless industrial appliances. All the provinces of France were explored for asphaltums, bituminous mastics, mineral oils, bituminous schists, sands, sand and limestones, and some thirty different varieties of asphaltum were exhibited in 1843, by Parisian companies upon the bourse. In the year 1845, in the departments of Ain, Landes, Puy de Dome, Bas Rhine, Haut Rhine, Saône et Loire, there were 16 mines, employing 489 workmen, and yielding an annual revenue of one hundred and twenty-nine thousand dollars. This bore about the same proportion to the amount of money invested, as the yield from the petroleum wells of northwestern Pennsylvania and Virginia bears to the capital stock of the companies working them. But asphaltum would not do all that the ignorant

newspaper writers of that day said it would, and soon fell in disfavor; companies crashed and thousands lost heavily. At present, bitumen, with a few exceptions, is restricted in its use to making roads, cisterns, and roofs watertight. The coal basin of Autun, in the department of Saône et Loire, contains largely worked beds of bituminous schists, producing on distillation an oil which is employed for gas-lighting. The bitumen of Seyssel is found in calcareous oolite, from which it is extracted by melting the broken rock in large cauldrons. In warm weather it has a thick pasty consistence and is tenacious, but in cold weather it is solid. It these respects it resembles the bitumens of Magdalena, Payta, and Trinity Island. The bitumen of Bechelbronn is viscous and of a brown color. It is put to many uses, and especially as a substitute for grease, in lubricating the axles of carriage wheels and the journals of machines. From these and similar applications, it has obtained the name of mineral oil, Stein oil, Strasbourg grease, etc. Like the bitumen of Coxitambo it is a pure hydrocarbon, containing 88 per cent. of carbon and 12 of hydrogen.

The bituminous rocks found in France are far surpassed by those of Dalmatia, on the northeastern shore of the Adriatic. The bituminous limestones found here seem to be so charged with liquifiable bitumen that they can be cut as easily as soap, and are formed into bituminous bricks for the sides of houses. When the walls have reached the required height they are set on fire, and burn until all the bitumen is consumed, leaving a white stone. The roof is then put on and the building completed.

In Italy petroleum is found in many places. That of Amiano in the Duchy of Parma supplies the city of Genoa with light. In the Duchy of Modena, petroleum springs are found at Saint Zibio, and in Sicily in the Val di Noto.

At Naples they appear to be connected with volcanic action, and to arise from the bottom of the sea near the southern base of Mount Vesuvius.

Passing over to the Ionian Islands we find large petroleum springs, of which the following account is condensed from the Colonial Statistics of the British Empire, published by Mr. R. M. Martin: The bitumen of Zante is contained in a valley or marshy plain, which is in the form of a segment of a circle, surrounded on three sides by abrupt and rugged ridges of hills. In the marsh within the circle are several wells or pits. The bitumen floats on the surface of the water in these wells. A dark substance continually forces its way from the bottom and boils up in large globules, which, enlarging till they ascend near the surface, then burst, and liberate a quantity of inflammable gas. Sometimes the globules are transparent and of singular brilliancy, rising to the top and bursting, while a coat of dark bituminous matter, in which they are invested, is thrown off. This dark substance is the *rock-pitch*, which, being specifically heavier than water, remains below, covering the sides and part of the bottom of the spring. The brilliant globules disengaged from it are pure *naphtha* or *rock-oil*, which forms a light oleaginous stratum above, reflecting various beautiful colors. The

intervening water is sweet and fit for use. The pitch is collected with large spoons into a pit adjoining the well, and thence thrown into barrels. It is exuded in the greatest quantities in the summer months. About a hundred barrels are annually used for paying the bottoms of ships, and for similar purposes.

Passing by the petroleum springs of Neuchatel, in Switzerland, and at Tagernsee, Bavaria, let us next consider the bitumens of

Asia.—The petroleum wells of southern Asia are of peculiar interest. They were dug thousands of years ago, and when Babylon was in its glory, its skilful artizans made far more extensive use of this facile material than has been found for it at the present day. In a paper communicated by the famous Asiatic explorer, Major Rawlinson, to the Royal Geographical Society of London, he calls attention to the bitumen collected in Kordistan, formerly the great satrapoy of Susiana. He states that even at the present day, it is drawn from pits, dug in precisely the same manner as described by Herodotus, nearly three thousand years ago. What a treat to the indefatigable illuminator of Herodotus, this striking confirmation and illustration of the text of his favorite author, must have been.

The natives all along the Euphrates and Tigris, use the petroleum found along the banks of these rivers to pay the bottoms of their vessels, and to burn in lamps instead of oil. And throughout Persia, in the provinces of Farsistan and Kerman, which border upon the eastern shores of the Persian Gulf, in Afghanistan, in the district of Cahut, petroleum springs are found. To the northward, in the Isles of Naphtha, which are situated upon the eastern shores of the Caspian Sea, a vast bituminous formation has its origin. It stretches away to the westward for over a hundred miles, and terminates in the hills of the Crimea. It reappears on the western shores of the Caspian, in the peninsula of Abskharon, which forms the eastern end of the Caucasian chain, where it is fully developed as a great deposit of brown coal in a ridge of argillaceous shale. In the neighborhood are the renowned wells of the fire-worshipping Badkuans, who use petroleum for both light and fuel. These wells are inexhaustible and refill themselves as fast as emptied. No traveler has given any account of the development, which we would be prone to expect, of petroleum through the Caucasus and Georgia. But in the peniusulas of Kerch and Taman, at the entrance of the Crimean Sea, and near the western extremity of the Circassian range, it is found in considerable quantities. In the great mountain range which skirts the Red Sea, along all the western coast of Arabia, petroleum springs and deposits of bitumen abound in strata wholly composed of oceanic animal matter: countless fossil shells, and rocky crevices, and hollow stones are filled with it; and in the fervid heat of that climate it drops down from the precipitous sides of mountain gorges. And when we follow this great line of volcanic action to the northward, along the valley of Arabia, through the Dead Sea, and up the valley of the Jordan, even to Mt. Lebanon, we find scattered along its course deposits of bituminous matter.

Finally, we come to the territories of Assam, and the Birman Empire.

In the former, as narrated in the Asiatic researches by Lieut. Wilcox, there are, to the east of Brahmaputra, great jungles which are full of the odor of petroleum. Beds of white mud are of frequent occurrence through this region, resorted to greatly by cattle and wild beasts of all kinds, which eagerly devour this substance, probably from its saline properties. Petroleum floats on the edges of these mud springs, but neither it nor the the coal which is likewise found in the neighborhood is used by the natives.

Near the banks of the Irawadi River, between Prome and Ava, many wells of petroleum have been sunk to a depth exceeding two hundred feet. They are found along with beds of brown coal, and co-extensive with a tertiary clay formation. In the province of Pegu, around the town of Rainanghong are 180 naphtha wells; 340 others are situated four or five miles to the northeast. The gross amount of oil annually obtained from the 520 registered wells is about a hundred thousand tons, or four hundred and twenty thousand hogsheads, amounting in value to $817,392.

In answer to a question, Mr. Leeds remarked that he had *not* observed any evidences of coral formation in the oil regions of Pennsylvania.

Mr. Coleman Sellers remarked, that coral containing bitumen was found through Kentucky, and that boring for oil had been undertaken in that region, while even in southern Illinois oil was found on the surface of some salt wells, and has been known thus to exist, and even to have been collected, for many years.

Prof. F. Rogers remarked, that in cutting the tunnel of the Chicago Water Works, under Lake Michigan, many boulders, saturated with petroleum, had been encountered, while again specimens of coral-bearing rocks from western New York, saturated with petroleum or bitumen, had also come within his observation.

Mr. Fleury remarked, that the common association of petroleum with salt water seemed to indicate that the former had resulted from the decomposition of sea-weeds, subjected in former ages to pressure and "*wet heat.*" He then described a process for the conversion of benzine into burning oil, by the catalytic action of lubricating oil, at a high temperature, this being accomplished at the same time with the distillation of the crude oil, in an apparatus of peculiar construction, patented by Adolph Millochau, of New York.

Secretary's Report.

Engineering Works.—It is now proposed to work the steep incline on the Mt. Cenis Railroad near the summit, by hydraulic engines, supplied with water from the lake on the top of the mountain, which will suffice for two engines, of 800 horse power each. Such machines, though rarely used in this country, have been largely employed in certain localities, as at Nesselgrabe and elsewhere, in upper Bavaria; and in the cutting of this very tunnel, hydraulic machines of peculiar action, analogous to that of the water ram, were used to compress air, which in turn operated the drilling apparatus.

The rapid progress of engineering works in the East, is worthy of note. The railroad from Alexandria to Suez, has now a rival in the canal through the Isthmus, which is open across, though not yet cut to its full depth. The railroad through Palestine is likewise completed, the city of Alexandria is lit by gas, and a telegraph runs through Morocco.

A railroad bridge has been constructed of Bessemer steel over the Sankey canal, England, the use of this material enabling the engineer to reduce by 40 per cent. the weight of the structure.

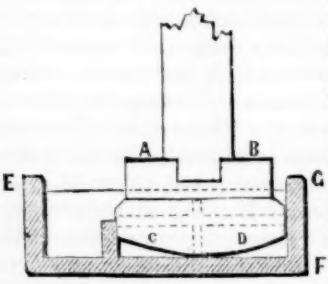
Mechanical Engineering.—Leading articles in some of the foreign journals and several patents in the same location, give expression to a difficulty in the direction of locomotive construction, which seems to press forcibly upon foreign engine builders and their customers, namely, the impossibility of combining great weight and tractive power with "flexibility" in turning curves, without overloading the driving wheels, and thus injuring the permanent way. These difficulties have long since presented themselves in this country, where our roads, carrying heavy material, such as coal and iron, over great distances, rendered some means of drawing at once long trains, by single engines, of the greatest financial importance. We have surmounted the obstacles and obtained the desired results. 1. By building "tank" or other very heavy engines. 2. By giving these an extended wheel-base of 8, 10, or 12 coupled driving wheels; and 3. Removing the flange from most of these drivers, so giving "flexibility" in turning curves.

We give, for the benefit of those interested in the experiment, the particulars of the apparatus lately constructed for the Franklin Institute, to repeat Perkins' experiment of cutting hardened steel with a soft iron disk rotating at a high velocity. A disk of steel, such as is used for circular saws, but annealed so as to be very soft, is mounted on a steel spindle, which carries also a three-inch cast iron pulley, and the whole is then carefully balanced until it will rest indifferently in any position, on two straight edges. This spindle, &c., is then mounted in *cast iron swiveled* bearings. A belt, 2 inches wide, on the pulley is driven from a 36-inch pulley on an ordinary shaft, which carries also a 10-inch pulley, to which motion is given by a 4-inch belt from a 48-inch pulley on the engine shaft. The engine was run 120 revolutions per minute, which would give, with every allowance for "slip," between 5000 and 6000 revolutions per minute to the disk. At this velocity the hardest files were cut like soft wood, with the production of a blaze of light and showers of sparks, without the least injury to the edge of the soft disk.

The constructors of this apparatus were kindly furnished by Mr. Joseph Saxon, of Washington, with a general description of the machine originally made by him for Jacob Perkins in London, and in the above mentioned apparatus this description was followed, except where the improvements of modern machinery, warranted a deviation. The most important of these deviations was in the use of *cast iron*

swivel bearings. In these the mobility of parts necessitates an equal distribution of the pressure and friction, over the whole surface of contact, and thus renders possible the use of a material otherwise so unfit as cast iron. The friction is in fact by this means brought between the steel and oil, and in no respect between the solid surfaces, at any point.

It may be well in this connexion to give some description of a means for supporting heavy upright shafting with the least possible friction, founded on the principle above mentioned, and not only in theory but in practice most efficient. The end of the upright shaft is secured in a large disk of cast iron A B, so proportioned that its lower face shall not have to bear a weight of more than 100 lbs. per square inch. This rests upon another heavy cast iron disk C D, with a plane surface above, but below slightly curved; which lastly is secured in the strong cast iron box or case E F, which is filled with oil to E G. A few radial grooves are made in the lower face of A B, and the centrifugal action generated by its motion, thus constantly pumps oil through an upright tube in the centre of C D and distributes it over the rubbing surfaces. The important feature in this arrangement, is that the great surface, makes it possible to keep oil always between the rubbing parts, so that no friction of solid surfaces can occur, while any tendency to unequal bearing of the surfaces, is at once corrected by the "rocking of C D upon its rounded base.



We describe this arrangement with the more pleasure, because it involves a principle of wide and various application, limited by no patent and free to the use of all.

Metallurgy.—The improvements and extensions of modern machinery have created a demand for some material much stronger than cast iron, and yet not much more costly, so that it may be used freely in the construction of extensive works. We are therefore glad to see that decided steps are being taken for the manufacture in this country of Bessemer steel, according to the improved processes which have reduced that department of metallurgy, to a condition of reliable efficiency. Two companies are already engaged on this work in America. Winslow & Griswold, of Troy, New York, who own the Bessemer patent, and have already produced excellent specimens of this steel, which they expect soon to send into the market, and the Pneumatic Steel Co., of Detroit, Michigan, who own the patents of William Kelley, and of Mr. Mushet. This last patent, covers the modification in the process consisting in the addition of iron, manganese, and carbon (generally in the form of the German Spiegel Essen, or our Franklinite, and charcoal) to over-refined Bessemer iron prepared in the way first devised. (Specimens and photographs of this steel, of foreign and domestic manufacture, were exhibited to the members.)

We have also to notice a process for the production of steel directly from the ore, proposed by G. Hand Smith, of Philadelphia. Pure oxide of iron, such as the magnetic oxide, for example, is crushed, washed, and packed in layers alternating with charcoal in the ordinary cementing furnace; after heating, a porous mass is obtained, which may then be rolled into plates.

A process for increasing the strength of cast iron by the addition of an alloy of zinc, lead, and tin, in the proportion of about 7 per cent., has also been presented by A. L. Fleury. This process is patented, and the amalgam prepared by W. M. Arnold, of U. S. Composition Iron Company, New York.

Mr. Fleury also described a process of manufacturing steel analogous to that of Bessemer, in which the decarbonization of the cast iron was effected by introducing into it, while melted, pulverized oxide, whose oxygen served to combine with and remove, the excess of carbon.

Mr. Lamborn mentioned that there had just been imported by the Penna. RR. Co., some 30 tons of Bessemer steel rails, this being the first large quantity of that material introduced in this country.

Prof. F. Rogers.—In connexion with these remarks about the locomotives, it is rather a curious fact that the subject of stationary engines has been opened again in England. Mr. Burleigh, who most members know as the celebrated writer on the strength of materials, has been estimating the motive power required for the railroads which go over the metropolis and those which go under the metropolis, and has been advocating stationary engines. He shows the advantages of the stationary engines from the fact that a great deal of time is consumed in getting up speed, and letting it down again, and it is proposed that the stationary engine shall push the train by the proper arrangements for the distance of a hundred yards, and permit it to go the rest of the distance by the impetus which the train has acquired, this being sufficient to enable it to pass the last station at the rate of 13 miles an hour.

Those members who have not noticed this, will find in the *Civil Engineers' Journal* a long account, which is quite interesting.

Since most engineers are opposed to it, it is barely possible that the thing may be tried, the principal objection which has been made to it lately, is the fact that the whole traffic depends upon a single engine. If the engine breaks down, or any serious accident occurs, the whole traffic must be suspended until repairs are completed. Of course, the danger of any disturbance, causing a breaking of the line, or the rail, is considerable, and as it cannot be repaired very readily, this is one of the most serious objections made to this system on the point of economy. It seems otherwise plausible. I mention it now as being curious, because in old times these stationary engines were largely used; we, however, use locomotives on heavy grades now, and the plan alluded to seems to be a retrograde movement.

After this, the meeting was, on motion, adjourned.

HENRY MORTON, *Secretary.*